HARMAN

Engineering Operations in Redeeming Overflowed Lands

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ENGINEERING OPERATIONS
IN
REDEEMING OVERFLOWED LANDS

BY

HARRIS JACOB HARMAN

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FOR THE

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IN

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May 25, 1914.

I hereby recommend that the thesis prepared under my direction by HARRIS JACOB HARMAN entitled ENGINEERING OPERATIONS IN REDEEMING OVERFLOWED LANDS be accepted as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

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INTRODUCTION.

All along the Mississippi and some of its principal tributaries are many large areas of land which are frequently covered with water during the spring floods. The United States Government has built levees in some localities to keep the rivers in their channels, and in many cases the land owners have grouped themselves together to form drainage districts and build other levees and drainage works for the reclamation of their lands. The engineering problems concerning the construction of these levees and the drainage of these lands by ditches and pumping will be described in this thesis.

To illustrate these problems the Louisa-Des Moines Drainage District No.4, in the State of Iowa, has been chosen.

I. DESCRIPTION OF THE DISTRICT.

The Louisa-Des Moines Drainage District No.4 is located on the Mississippi River about eighteen miles above Burlington, Iowa, directly across the river from Keithsburg, Illinois. It is bounded on the north by the Iowa River, on the east by the Mississippi River, and on the west by the Iowa River and the bluffs west of the Mississippi River. The southern boundary is an arbitrary line established at the time of drawing up the petition. The district contains about 16,000 acres, and is about seven and a half miles in length and three and a half miles in width.

During the years 1892-96 the United States Government completed a levee for river improvement which extends from the

bluffs along the south side of the Iowa River to its mouth, thence down the Mississippi River to the mouth of Flint Creek, thence to the bluffs along the Mississippi River, enclosing an area of 44,000 acres. The Louisa-Des Moines District is located in the northern portion of the area enclosed by this levee. South of this district and adjoining it is the Des Moines County Drainage District No.1, which includes the remainder of the area enclosed by the levee.

The Village of Oakville is located in the west central part of the Louisa-Des Moines Drainage District; but with some surrounding land is not subject to assessment, because previously organized as a separate drainage district.

II. HISTORY OF THE ENTERPRISE.

The petition for the organization of the district, signed by twenty-five free-holders of the state, was filed on June 20, 1907. Mr. J. A. Schreiner was appointed engineer for the district on October 16, 1907; and his report was adopted in the early part of May of the same year. In September, 1908, Mr. Jacob A. Harman of Peoria, Illinois, was appointed engineer of construction. During the summer of the following year a complete topographic survey was made for the purpose of assessment. The first call for bids, that of the ditch work, was issued on November 27, 1908; and soon afterwards bids were asked for the work on the pumping station. The first pump was put into operation on May 11, 1909, and the second on June first, 1909, altho even at the later date the building was completed only as far as the foundations. The pumping plant was completed during

the month of August, 1911.

III. SUCCESSIVE LEGAL STEPS REQUIRED.

Altho not directly connected with the engineering operations, the engineer must have a thorough knowledge of the drainage laws of the state in which he is working. Such ~~These~~ laws differ widely in the various states. The following is a synopsis of the drainage laws of the state of Iowa, under which the Louisa-Des Moines Drainage District was organized.

1. Filling petition for organization with bond to cover costs if not organized.

2. Supervisors appoint engineer to make preliminary report.

3. Engineer's report filed, with plans and recommendations.

4. Supervisors examine the report of the engineer including plans and recommendations. If the engineer recommends the organization of the district, the supervisors either approve or modify his report or appoint some other engineer to make a further report.

5. When the plans have been approved by the supervisors, the land owners are notified.

6. The land owners are given a hearing before the supervisors.

7. If claims for damages are filed, the supervisors appoint three appraisors of damages.

8. The appraisors' report is filed with the County Auditor, and notice is given for a hearing before the supervisors.

9. The supervisors consider the damages, the cost of improvement, and the benefits; and declare either for or against the organization of the district.

10. After the organization of the district, the supervisors appoint an engineer, who makes a complete topographic survey of the district. The purpose of this survey is to determine the amount of benefit derived, and also for use in the design of the ditches and levees.

11. Bids are received and the contracts awarded.

12. The commissioners are appointed by the supervisors to make the assessment of benefits and spread the tax for the amount of money required for construction, incidental expenses and damages.

13. The commissioners make their report to the supervisors. The County Auditor gives notice of date when objections against the assessment roll may be made.

14. The supervisors hear the objections to the assessment roll and either confirm or change it.

15. Any objection to the assessment may be appealed to the Circuit Court.

16. The supervisors may divide the assessment into installments payable over a period of nine years, and sell bonds bearing not to exceed six percent interest, in anticipation of the collection of the taxes.

17. After the awarding of the contracts, and pending the collection of the money from the taxes or sale of bonds, the County Auditor may issue interest bearing warrants on the District to be paid out of the future funds, for construction and other expenses. The construction work is usually begun

before the bonds are sold or the taxes collected, but may be deferred until the funds are in the treasury.

18. The collection of the drainage tax is carried out thru the regular tax levying and collecting offices of the county, and the funds are held by the County Treasurer until paid out on warrants issued by the County Auditor, on order of the Board of Supervisors, which orders are based on estimates of the engineer.

IV. TOPOGRAPHIC CONDITIONS.

Before the Government levee was built the greater part of the District was covered with water when the spring floods came down the Mississippi and Iowa Rivers; but when the rivers went down the land was partially drained by a net work of sloughs. During the construction of the levee automatic flap-valves were placed in it at the mouth of each of the sloughs. When the river was at low-water stage, the water from the District was only partially drained through the valves; but during high water these sloughs formed large reservoirs in which the water collected and remained until the river went down to a low stage. In the spring the sloughs were so full that there was no surface drainage; and hence the land was wet, soggy, and unfit for tillage.

To drain these reserviors it was necessary to collect the water at one or more central points, and pump it over the levee. By deepening some of the sloughs and constructing connecting ditches, it was possible to bring the drainage water of the entire District to the intersection of Iowa Slough with the Government levee, which is at the extreme south end. The pump-

ing plant was placed at this point.

V. SURVEYS.

After the organization of the district it is the duty of the engineer to obtain data on which to base estimates, and to design the drainage system. These data are obtained by surveys made either by the engineer after organization or at some previous date. The surveys for this work can be placed in three groups, namely, preliminary surveys, topographic surveys, and location surveys. These will be discussed under separate heads.

PRELIMINARY SURVEYS. The preliminary survey is to determine the advisability of the proposed drainage district, to develop preliminary plans, and for use in estimating the cost. The thoroughness of the survey is usually determined by the amount of money that the interested parties are willing to appropriate. The ideal survey would be a complete topographic survey made by the stadia method; but unless this method is required by law, as in the state of Missouri, it is very seldom used on account of its high cost.

The method used in a great many cases, and the one used in the District under consideration, is that of running levels over the routes which appear to be most feasible for the proposed ditches, and taking soundings in the lakes and sloughs. This method permits a fairly accurate estimate of the cost of the undertaking and a determination of the feasibility of the project.

TOPOGRAPHIC SURVEYS. The laws of Iowa require, for

assessment purposes, that levels be taken on each forty-acre tract and soundings be taken in all lakes and sloughs in the district. The most common way of obtaining these data is to run levels on the section and quarter-section lines, and to take the depths of sloughs enroute.

In the Louisa-Des Moines Drainage District, however, a complete topographic survey was made under the direction of Mr. Jacob A. Harman, who had been appointed engineer of construction. This survey was carried on by the regular stadia methods, a base line being run from north to south thru the district, and circuits being run from it. In the open country the circuits started from the base line, followed a section line nearly to the boundary of the District, thence about parallel to the base line to the next quarter section line, and thence back to the base line. The instrument stations were placed about six hundred feet apart, one rodman being sent out about twelve hundred feet on each side of a station, and shots being taken at intervals of about three hundred feet. All buildings, fences, cultivated areas, sloughs, lakes, ditches, and depressions were taken with great detail.

In the wooded country the progress was much slower, and it was necessary to resort to different methods. Here instead of running the circuits in nearly straight lines as was done in the open country, the course of the larger sloughs was followed. This method saved the cutting of a great deal of brush and gave the location of the sloughs accurately. Lines were cleared in several directions from each station, and enough shots were taken to cover the ground thoroughly.

Somewhere within a space of five or six hundred feet

from the bank of the river is a ridge, usually high enough above the surrounding country to make the location of the levee on it advantageous from the standpoint of construction. For this reason topography is taken with great detail for some distance back along the shore of the river.

In this type of work where speed and economy go hand in hand, it was found that the party which best served the purposes consisted of five men, a topographer, who was chief of party, an instrument man, and three rodmen. The topographer carried a sketch board about two and a half feet long and one and a half feet wide, hung about his neck, on which he made free-hand sketches on sheets of paper eight and one half by eleven inches. This method was found to be much more satisfactory than the old method of making sketches in the note books, on account of the fact that the sketches could be made in more detail, and in platting up the notes no time was lost in deciphering the sketches. In wooded country where the work required the cutting of a great deal of brush, one or two extra rodmen were sometimes used, the rodmen cutting their own lines.

LOCATION SURVEY. The location survey is made after the plans have been adopted by the supervisors or the commissioners, as the case may be. For the levee location the line is run, and the center and slope stakes are set every hundred feet. Levels are taken at every station so that the exact yardage may be computed. In level country, in locating the ditches center-line stakes are the only ones set. Levels are taken as in the levee location. In rough country slope stakes also are set. In open country it was found that a three-man party was the most econ-

omical. The party consisted of a chief, who ran the instrument, and two rodmen; but in the swamps or where the country was heavily wooded, it was best to have enough axemen to keep a line cleared so that the instrument men could proceed without delay.

During the course of construction, surveys are made each month to determine the amount of work done by the contractors on the levees and ditches. These surveys are made by taking cross-sections at every station. From these cross-section notes estimates are made of the month's progress. The contractors are paid from these estimates, a certain percent being retained each month to be paid when the undertaking has been completed.

VI. DESIGN OF LEVEE.

The principal factor to be considered in the design of a levee are economy of construction and maintenance, permanence of structure, and suitability to form a part of future construction. The last consideration is important, since the increase in the height of the river bed caused by the gradual deposit of sediment makes necessary a future increase in the height of the levee; and therefore great saving will result when future construction can be made without radical change in the original levee.

The design should follow some general plan, and should be based on the principles underlying the flow of rivers. A thorough study of the stream is necessary, the places where the erosion occurs, how it is occasioned, the nature of the banks, their height, and the material composing them. Angles should be avoided as much as possible; but where a change of direction is necessary, the angle should be rounded off by as easy a

curve as is consistent with good design. The line of the levee should as far as practicable follow the bank of the river; but consideration should be given to a high and firm foundation, and the line should be selected with this continually in view.

The cross section of a levee will vary with the conditions to be met in that particular locality, that is, the character of the foundation, the nature of the material of which the levee is to be constructed, and the exposure to wind and waves. The more usual dimensions are 8 to 10 feet on top, altho some are as narrow as 3 feet, and a "combined" slope of five or six to one.

If it is necessary to make the levee extremely high, what is known as a banquette is constructed on the rear face. A banquette is nothing more nor less than a bench or terrace which increases the width of the lower portion of the levee, and the stability of the whole. The object of the banquette is to keep the levee from sloughing off when saturated by water, which it does by keeping the surface of saturation well within the embankment. The bench is usually about twenty feet wide and has a rear slope of something less than that on the river side.

Theoretically, for a cross-section of a levee of equal strength in all parts, side slopes of one to one are all that are required, but in practice this must be modified according to the angle of repose of the material. Steeper slopes than one to three cause the material on the landward side to slip, and on the river side the material is too easily washed away.

The standard sections used on these levees are expected to withstand the water to within three feet of the crown of the levee without excessive saturation or change of form. When sub-

jected to water above the three-foot line, they are not considered safe provided there is practically no wave action. The tendency at the present time is to increase the margin of safety by keeping the water line about five feet below the top of the levee.

One of the most important factors of a levee is its height. The determination of this needs special consideration, since failure is a foregone conclusion if water is allowed to overtop the crest. It is therefore necessary that all levees be built to a height above that of the highest flood level.

The height depends in a measure upon the position of the levee with reference to the stream, and upon the direction of the current. For example, an embankment so placed that it lies at an angle to the direction of the current will need to be much higher than one parallel to it, for with the former the water tends to bank up against the levee, while with the latter such is not the case.

Another important matter which must be given consideration in the construction of a levee is the foundation. This is a case, not of selection, but of dealing with the material at hand. In all cases the ground on which the levee is to be constructed must be cleared of all material which will decay. The ground must then be plowed so that the material for the levee will unite with the foundation leaving no cleavage plane. When a levee is to be built to a height of more than ten feet an exploration trench is usually required. An exploration trench is a ditch about four feet wide and five feet deep, for the purpose of discovering any buried logs, animal dens, or any cause for forming of a passageway through which the water may pass under

the levee.

The barrow-pit, or pit from which the material for the levee is taken, should be on the outside of the levee, and ordinarily not nearer than twenty feet to it. No material should be taken from the inside. A barrow-pit on the inside of the levee has the same effect as increasing the height of the levee equal to the depth of the pit. When a levee is placed near the bank of a stream, the barrow-pit should not be made continuous; but transverse bars should be left across it, so that the stream will not form a new channel along the base of the levee.

The material of which a levee is constructed is usually that nearest at hand, but some materials are better adapted to such use than others.

VII. DESIGN OF DITCHES.

Obviously, in designing any system of drainage ditches, it is desirable to utilize the present channels as far as practicable, since such a course cuts up the land the least and reduces the cost of construction. This will usually necessitate the deepening of these streams in places, and sometimes thruout their entire length. In the natural channels of most small streams there are usually so many small curves that it is necessary to cut short ditches across bends, thus straightening the channels. By thus straightening and deepening the channels, streams that formerly overflowed their banks during the spring floods are made of adequate size to carry the water. In designing the drainage system for most districts many new ditches are included in the scheme in addition to the natural channels.

When new ditches are constructed they are located as far as possible on section lines or property lines, so that the farms will not be divided.

Theoretically, the slope and cross-section of a ditch depends entirely upon the area drained, the rainfall, and the runoff; but an engineer who has had wide experience in drainage work has learned that there are several minor factors that must be taken into account, and hence he is frequently required to modify theoretical results in accord with experience. In opening a new country it is necessary for the engineer to study rainfall; but even then, experience on other projects will play a large part in the design of the ditches. In the Mississippi valley in designing ditches it is considered sufficient to provide a channel for about one half to three fourth inches of rainfall over the entire area drained, while in determining the pumping capacity only one fourth to three eights of an inch is used.

After having determined the amount of run-off to be provided for and also the area drained by each ditch, the next point to consider is the slope of the ditch. The slope of the ditch depends to a great extent on the slope of the land, but the former slope must not be so great that excessive erosion will occur, nor so small that the water is not carried off in a reasonable time. A great many formulae have been developed for determining the cross-section of a ditch, but the one in most common use is the Chezy formula, together with Kutter's formula for the determination of the constant "c".

Chezy formula: $v = c\sqrt{rs}$, where

c = a variable coefficient.

r = hydraulic radius = a/p = area divided by wetted perimeter.

s = slope = h/l = fall of water surface per unit of length.

Kutter's formula:

$$c = \frac{\frac{1.811}{n} + 41.65 + \frac{0.00281}{s}}{1 + \frac{n}{\sqrt{r}} \left(41.65 + \frac{0.00281}{s} \right)}$$

where "n" is the coefficient of roughness. No little uncertainty attends the determination of the value of "n", but after careful measurements made under the direction of the United States Reclamation Service, the following approximate values were given for channels described.

0.020	Channels of fine gravel; canals in earth in good condition, lined with well packed gravel, partly covered with sediment and free from vegetation.
0.0225	Channels in earth in fair condition, lined with sediment having occasional patches of algae, or loose gravel without vegetation.
0.025	Canals and rivers of fairly uniform cross-section and slope in average condition.
0.030	Canals and rivers in poor condition with bed and banks partially covered with debris.
0.035	Canals and rivers in bad condition, channel strewn with stones, and about one third filled with vegetation.
0.040	Canals half-full of vegetation and having rough banks.

The value of "n" used for most ditches is 0.025.

A more simple formula devised by Mr. C. G. Elliott is sometimes used, and is said to be nearly as accurate as Kutter's formula. Elliott's formula is:

$v = \sqrt{(a \div p)\ 1\tfrac{1}{2}h}$ where

$Q = a\ v$.

v = mean velocity in feet per second.

a = area of water way in square feet.

p = wetted perimeter = length of bounding line of cross-section of that part of the channel which is under water.

h = fall in feet per mile.

Q = discharge in cubic feet per second.

A = number of acres.

R = run-off per acre.

The number of acres which can be drained = $A = Q/R$.

The side slopes of ditches are usually specified one vertical to one horizontal, but sometimes these dimensions are varied. The width of the bottom of the ditch depends largely on the type of machine used in excavation. About the narrowest ditch that can be economically dug with a dipper-dredge of the floating type is ten feet, while some types of dry-land dredges will dig a ditch as narrow as can be used. The drag-line machine, another type of dry land excavator much used in ditch work, will dig to a width of about four feet.

VIII. DESIGN OF PUMP PLANT.

One of the most important problems which the drainage engineer must meet, is the design of the pumping plant. The plant should be designed with a view to certainty of operation at any time, to economy of operation, and to cost of maintenance. The first matter to be considered is the choice of the

type of prime mover and pump which should be used. The conditions which govern their selection vary considerably in different localities, chiefly on account of the difference in head, the relative accessibility of the plants, the cost of fuel, etc.

In selecting the type of prime mover, consideration should be given to internal combustion engines, electrical motors, and steam engines, all of which have been used in this class of work. Prime movers of the internal combustion type have some strong arguments in their favor; but before deciding on an installation of this kind, the availability of proper operatives must be given careful consideration. Electric motors are suitable for small plants located near an available supply of current; and the convenience of operation will often offset the increased cost of power. Properly designed steam-driven plants have very good fuel economy, and can readily be run at the various speeds necessary to economical operation under different heads.

Several types of pumps have been used for this class of work, including the propeller-lift pump, the paddle or scoop-wheel pump, and the low-head centrifugal pump. The propeller lift pump and the paddle-wheel pump, as constructed in this country, are not durable types of construction. Scoop wheels of a durable type of construction have been used very extensively in England and Holland. These plants operate quite economically at low pumping heads; but are very expensive to install properly, and have not been developed for the extreme ranges of head encountered on the Upper Mississippi.

Taking all these facts into consideration, the type of prime mover and pump which at this time appears to be best adapted

to the average conditions are, for large installations, the steam engine and low-head centrifugal pump; and for the smaller installation, internal combustion engines or electric motors.

The Louisa-Des Moines pumping plant differs in only a few details from most other pumping plants on the Upper Mississippi river; and therefore nothing more need be said concerning its design. The plant is steam driven, and its principal equipment consists of one 300 horse-power Erie-City-Iron-Works horizontal boiler, equipped with an open-feed water heater, induced draft apparatus, and heater and feed pumps. In addition to the regular boiler gages a recording pressure gage is mounted in the boiler room. There is also a 10 horse-power vertical boiler, which is intended for cleaning the main boiler and starting the auxiliaries. The pump room is equipped with two Erie-City-Iron-Works 250 horse-power horizontal tandem-compound condensing four-valve steam engines, each of which is directly connected to a 50-inch Worthington centrifugal pump. While these pumps are called "50-inch pumps", they are made from the regular 45-inch pump patterns with the exception that the discharge opening of the pump volute is expanded to fifty inches. The rated combined capacity of the pumps is 225 cubic feet per second (100,000 gallons per minute) when working against a static head of 12.5 ft. Each of the main engines is fitted with a revolution counter. The pump station is lighted by a small electric plant. The main engine is lubricated by a continuous oiling system. The oil from the bearings is collected and automatically pumped into a filter located above the engines, from which it is returned by gravity to the engine bearings.

IX. SPECIFICATIONS.

Since various parts of the work are let to different contractors, the engineer must prepare separate specifications for the open ditches, the levees, the sluice gates, pumps, engines, boilers, pump house, and residence for the stationary engineer. All of the specification issued during the construction of the Louisa-Des Moines Drainage District would be too bulky for inclusion in this thesis, and besides there would be more or less repitition; and therefore only a sample of the specifications for each type of work have been included. These specifications may be found in the appendix.

X. ESTIMATE OF COST.

The method of estimating the cost of ditches and levee is much the same as that used in railroad earth work; but on account of less precise work being required in construction, the estimates need not be so accurate. After the profiles of the ditches have been drawn and the grade lines established, the cuts or fills are measured, recorded and averaged. For convenience in figuring, tables showing the number of cubic yards for a hundred feet of the average cut or fill were compiled and from these the desired volume is read directly. If the cross-section is very irregular, the more accurate method used in railroad work, that of computing yardage from average end areas, is used. The price on which these estimates are figured is a matter of experience, and varies according to the number of yards of dirt to be moved, its accessibility, the character of dirt, the price of labor, etc. Ditch work usually varies from eight to ten cents

per cubic yard, and levee work from twelve to fifteen cents per cubic yard.

The estimate of cost of a pumping house is made in the same manner as that of any other building. For data on the cost of machinery the engineer must rely on the manufacturer. In cases where the engineer has had a great deal of experience in pump-plant construction, curves can be drawn from which the cost per horse power for all kinds of plants can be taken directly. This eliminates the detail work of estimating, and in most cases is accurate as detailed estimates, so, for in detail estimating many items are likely to be overlooked.

XI. CONSTRUCTION OF DITCHES AND LEVEES.

METHOD. Ditches and levees are constructed by several different methods depending on the character of the soil and the size of the ditch or levee. The most common tools in use today for this kind of work are the drag excavator, the floating dipper-dredge, and the hydraulic dredge. Until about twelve years ago none of the above methods were known, the levees and ditches being usually constructed by the horse and slip-scraper method. This method is now used only in extreme cases.

The floating dipper-dredge consists of a steam shovel mounted on a barge. The dipper ordinarily ranges from 3/4 yds to 2½ yds. These machines are moved along the ditch by what is known as "kicking", that is, the dipper is allowed to rest on the bottom of the ditch, and then when power is applied the barge moves either forward or backward as the case may be. The dredge is kept in place while at work by long timbers, called spuds,

which reach down into the soft mud, and which are raised and lowered by steam power.

The drag excavator, sometimes called the drag-line excavator, is a type which operates from the natural surface of the ground, and takes its name from the type of bucket employed. The bucket is in the form of a slip-scraper, is filled in the same manner as is that form, is raised by a wire cable which passes over the end of a boom and thence to the winding drum operated by the engine, and the bucket is swung to one side by a cable, and is tripped by another cable. The machine is moved on rollers placed on tracks of timber, and may travel in the middle ahead of the ditch or along one side of the ditch. The buckets for this kind of work are as large as 2½ yards capacity. By means of a long boom this form of excavator can deposit the earth at a greater distance from the ditch than the dipper dredge; and therefore it is better adapted for the construction of levees and embankments. This machine can be used for either large or small ditches wherever the ground is sufficiently stable to support the machine.

Hydraulic or suction dredges are principally used for raising sand or mud. The machinery is carried on a barge, and the barge is moored in the same manner as the dipper-dredge. The material is pumped by a centrifugal pump through a sectional pipe which reaches to the bottom of the stream. The pumps used will raise and pass through them stones and other hard substances of any size that will pass through the suction pipes. The material is discharged either into a hopper or through pipes or troughs onto the shore. When working in heavy sand, the material left in the hopper represents about 50 per cent of the water and sand

raised, and in clayey sand about 40 per cent.

Two other types of buckets, the orange-peel and clam-shell, are suitable for excavation and moving material which is sufficiently soft to permit buckets of that class to be filled. The orange-peel is particularly useful in building levees.

XII. MAINTENANCE AND OPERATION OF PUMPING PLANT.

After the drainage ditch has been organized, the many preliminary difficulties surmounted, the drainage system properly designed and constructed, the construction contracts closed, and the services of the engineer dispensed with, the affairs of the drainage district are left entirely in the hands of the commissioners, who in most cases are not versed in the proper maintenance and economical operation of power plants. Most power plants are a vital part of the enterprise with which they are connected, but no particular anxiety is felt by the owners on that account. However, the conditions surrounding drainage pumping-plants are so entirely different from those surrounding the average power plant, that the operation of the former becomes a matter of serious consideration. Experience shows that the average drainage commissioner has a tendency to economize in the maintenance of a plant to such an extent as to make it impossible to operate it properly when the water conditions are the worst and the demand on the plant is a maximum. This false economy has in many cases resulted in immense damage to the crops in the district, and has shaken the confidence of investors in projects of this character. The plant should always be maintained in such condition as to be ready for efficient operation at a moment's notice. This requires

that there shall be somebody in charge who is capable of keeping the plant ready for instant service and who is capable of determining the conditions necessary for its most efficient operation. Great saving can be made by always operating the plant under the most economical relation of speed to head. It is readily seen that any saving which can thus be made is of vital importance, since the expense of operation is a perpetual **tax** against the lands.

Lack of authentic information regarding the capacity and efficiency of low-head centrifugal pumps at various heads and speeds, seriously complicates the problems of determining the most economical operating conditions; and even when correct information regarding the pump is available, the friction of the suction and discharge piping is usually such a large percentage of the total head that each plant becomes more or less a problem of its own, and should be studied individually.

Experience indicates that the only proper method of determining the most economical pump speeds and steam pressures for the various operating conditions is by making a series of tests on each particular installation of pumps, engines and boilers, with various speeds and steam pressures at the different heads encountered in practice. Having secured these data an operating chart can be made up for the plant, showing the proper operating conditions for the different heads. On account of the difficulty in securing the proper test conditions, it is necessary to be in readiness for testing at all times, and to make the tests without delay when the proper conditions arrive.

The experience of many drainage districts indicates that

it would be highly profitable to the land owners, as well as affording them greater security against break-downs at the plant, to place the operation of their drainage pumping plants in the hands of a competent drainage engineer who would make tests from time to time, purchase the necessary fuel and supplies for the plant, keep the accounts and pay the bills, as well as supervise the operation of the plant and look after its proper maintenance. Such an officer should be required to furnish an acceptable bond in an amount sufficient to secure the drainage district against any pecuniary loss. He should also make written reports at the regular meetings, setting out in more or less detail the conditions in the district and at the pumping plant, including a report of all expenses incurred since the preceding report. A full report for each year should be made at the end of the year, in which the cost of operation, pumping conditions, amount of water pumped, and other items of interest should be reported in detail so as to make a full and complete record of the year's operations.

XIII. TOTAL COST.

1. CONSTRUCTION. The following is a statement of the cost of construction of the pumps, open ditches, and tile drains. The data concerning the cost of the levee ~~is~~ are only approximate, since it was built by the U. S. Government several years previous to the organization of the District and no exact data is available. The data given for the other items is the actual cost.

LEVEES at 14.2 cts per cu. yd.	$ 144,000.00

PUMPING PLANT:			
Pumps, engines, boilers, etc.		$ 29 770.00	
Pump house		20 772.67	
Residence for station engineer		1 941.10	
Telephone		25.00	$ 52 508.77
OPEN DITCHES:			
76 975 cu. yds.	at $0.14	10 776.50	
18 048 " "	at 0.17½	3 158.40	
139 748" "	at 0.09½	13 625.43	
16 495 " "	at 0.12	1 979.40	
Sluiceway		830.00	30 369.73
TILE DRAINS			14 740.68
ENGINEERING AND MISCELLANEOUS EXPENSES.			19 698.18
Total cost			117 317.36
Total cost per acre			20.10
Cost per acre exclusive of levee			9.025

Owing to the fact that the U. S. Government built a levee around the district for river protection, it was unnecessary for the land owners to meet this expense; and therefore the total cost exclusive of levee is less than half of the average for projects of this nature.

2. OPERATION. The following is a statement of the cost of operation of the pumping plant of the Louisa-Des Moines Drainage District No. 4 for the years 1910, 1911, 1912. This includes the cost of maintenance, repairs, and upkeep.

During the years 1910-14 the cost of maintenance of the

ditches has been practically nothing; but it would be fair to estimate about 5 cents per acre per annum for maintenance of the ditches in addition to the cost of pumping as above.

YEAR	TOTAL COST PER ACRE.
1910	35.6 cents
1911	45.9 "
1912	51.8 "
Average	44.4 "

XIV. ECONOMIC RESULTS.

Thus far in this discussion nothing has been said concerning the advantage of land drainage or of the value of overflowed land that has been redeemed. Land over which the rivers have spread every spring for many years past, is about the only rich soil in this part of the country, which has not been robbed of a considerable part of its fertility by continual cropping. These overflowed lands for many years past have accumulated large stores of fertility, although in some cases they may be somewhat lacking in a single element, such as lime or phosphorus. However, the deficiency is small in comparison with most of the lands which have been in cultivation for any considerable number of years. Further, the deficient elements, usually lime or phosphorus, can be readily and cheaply provided. By the addition of comparatively small amounts of fertility these lands are in condition to produce very large crops for a comparatively long series of years, although of course this land like all other will become depleted in time unless the elements of fertility removed by the crop are restored by some form of rotation or fertilization.

Before being drained these overflowed lands have very little value, and can be bought at comparatively low prices. For example, the average value of the lands in the Louisa-Des Moines Drainage District before the construction of the Government levee ranged from $10 to $25 per acre; but after the levee was built the price was from $25 to $75 per acre. The land to be had for the former price was that which was low and was not affected by the levee, and that to be had at the latter price was so high that it could be put under cultivation without underdrainage of the land. The value after the completion of the drainage work in the district ranged from $125 to $175 per acre; and that of corresponding land in adjacent districts ranged from $100 to $150 per acre.

The law permits land owners to cooperate in forming a district, and to issue bonds for the improvement; and the fact that the assessments for the improvement are spread over a number of years has greatly stimulated the redemption of these overflowed lands. The drainage law making possible such drainage districts has been of material advantage to the small investor, since it enabled him to bring the land into a high state of cultivation at a comparatively small annual expense. Further, since the cost of the redemption is small in comparison with the ultimate value of the land, drainage bonds are known to be a good class of investments; and therefore the redemption of these overflowed lands has also been of advantage to the capitalist in furnishing him an investment returning a small but certain income.

APPENDIX

SPECIFICATION FOR LEVEE

INSTRUCTIONS TO BIDDERS:

LOCATION. Map of the locality and plans and profiles of the work may be seen at the office of the Harman Engineering Co., Engineers for said District, at 120 Fredonia Avenue, Peoria, Illinois, and at the office of the County Auditor, at Wapello, Iowa.

EXAMINATION OF SITE. Bidders, or their authorized agents, are expected to examine the map, plans and profiles, to visit the locality of the work and to make their own estimates of the facilities and difficulties attending the execution of the proposed work. It is understood that the quantities given are approximate and that no claim shall be made against the Drainage District on account of excess or deficiency in the same.

BIDS AND CONTRACT. a. Bids shall be made out in accordance with the Form of Bid accompanying these specifications and the prices stated in writing and figures. Said bid shall be placed in an envelope, sealed and addressed " , and endorsed " .

b. Each bid must be accompanied by cash or a certified check in an amount equal to ten (10%) per cent of the amount of the bid, enclosed in a separate envelope from that enclosing the bid, and if a certified check the same must be certified without qualification or reservation and drawn on some National bank or Iowa State bank; said check to be made payable to the order of . No. 15, cash or certified check in no case to exceed Ten Thousand ($10,000) Dollars. The

envelope enclosing the cash or certified check shall be addressed plainly upon the outside with the name of the depositor and with the statement, that the envelope contains cash or certified check.

c. The party to whom any contract may be awarded will be required to execute the contract with approved sureties within ten (10) days from the date of notice of the acceptance of the bid. In case of failure or neglect to do so, said party will be considered as having abandoned said bid and the deposit in cash or check will thereby be forfeited to the said Drainage District as liquidated and confessed damages, and thereupon the work may be let to the next lowest bidder or re-advertised and re-let as the party of the first part may determine. The cash or checks of unsuccessful bidders will be returned upon the awarding of the contract on which they have bid and the filing of acceptable bond.

d. The bond to be furnished by the successful bidder shall be personal or Surety Company bond in a sum equal to twenty-five percent (25%) of the estimated amount of the contract, which bond or bonds shall be conditioned upon the faithful performance of the things specified to be done in these specifications and the contract, subject to the approval of the party of the first part.

e. Bids will not be considered except from parties furnishing evidence, satisfactory to the party of the first part, of necessary facilities, ability and pecuniary resources to fulfill and carry out conditions of the specifications and contract.

DESCRIPTION OF WORK. a. The work has been put into three (3) Sections, which may be awarded separately or to one or more

contractors, but bids which do not cover all the work in one section will not be considered.

The Sections comprise the following work, viz.:

....

....

The above described work includes all cross-overs, banquettes, clearing and preparation of right-of-way and other work incidental to this contract, except as herein otherwise specified.

b. The Contractor shall be required to prepare the base of the levee and to do all other work as set forth in the specifications as a part of the work for the prices named in the bid for excavation of ditches and for fill for levee, except as hereinafter provided for.

INFORMATION REQUIRED. Bidders shall state under oath the names and addresses of all persons or Corporations interested financially by pooling or otherwise in their bids of there be any whose names do not appear upon the bids as submitted. If any bid is made a Corporation names of the Executive officers and their places of residence shall be given.

COMMENCEMENT AND COMPLETION OF WORK. a. Sections, I, II and III shall be commenced not later than March 1, 1914, and be completed not later than December 31, 1914.

b. Bidders who cannot conform to these requirements as to beginning and completion of the work may state in their bids what conditions they would make as to beginning and completion of said work and such bids will be considered and passed upon in the interest of said Drainage District, as the party of the first

part in its best judgment may determine.

GENERAL CONDITIONS.

GENERAL. A copy of the notice, instructions, conditions and spedifications will be attached to the contract and form a part of it. The plans and profiles heretofore approved by the Supervisors will form a part of the specifications.

SUB-CONTRACT. Should the Contractor sub-let any part of the work, he will not be released from any responsibility he may have assumed in executing the contract for this work.

INTERPRETATION. The Contractor will not be allowed to take advantage of any error or omission in the specifications, as full instructions will always be given by the Engineer, should any error or omissions be discovered. The decision of the Engineer, as to quality and quantity of material, work done and workmanship, shall be final.

PENALTY. The party of the second part shall forfeit to the party of the first part, as confessed and liquidated damages, the sum of .... per section,..........per day for each day and every day that the work or parts of work as herein provided shall remain unfinished, after the day set out for its completion in the Instructioms to Bidders.

EXTENSION OF TIME. a. If extraordinary or unforseen conditions supervene which prevent the work being completed within the period stipulated in the contract, the party of the first part may, upon the recommendation of the Engineer, waive the time limit

and extend the time for the completion of the work. Should the original time limit be thus waived, all expenses for engineering and inspection and other actual loss and damage to the Drainage District, due to the delay beyond the time originally set for completion, ~~shall be beyond~~ not ~~the time originally set for completion~~, shall be determined by the Engineer and deducted by the party of the first part from any payments due or to become due to the Contractor: Provided, that the party of the first party may remit said charges for so much time as, in its judgment, may be equitable: Provided, further, that nothing in these specifications shall affect the power of the party of the first part to annul the contracts as therein provided.

b. Such extension shall not be granted except upon request in writing by the Contractor to the party of the first part and good cause shown; and no such extension shall be valid unless the same is in writing.

DAMAGES, EXPLOSIVES, ETC. a. The Contractor shall not be entitled to any damages for any hindrance or delay from any cause whatever in the progress of the work or any portion thereof, as the Contractor, in submitting his bid, takes the chances for the occurrence of such delay; but such hindrance may, in the discretion of the party of the first part, entitle the Contractor to such extension of time for completing the work as may be determined by the Engineer.

b. Subject to the approval of the Engineer, the Contractor may erect tents, shanties and storage buildings, and the Contractor may provide his own lodging camps, properly equipped, at which laborers and teamsters employed by him on the work will be required

to lodge unless otherwise directed by the Engineer. It is further understood that whenever dynamite, giant powder or other explosives are to be employed on the work, it shall be handled by persons experienced in its use, and in such manner as to in no way hazard the safety of the men employed about the work, or the safety of the work itself. All explosives shall be stored in the manner provided by law. The Contractor assumes all liability for accidents due to explosives.

c. The Contractor assumes the responsibility for the safe-keeping of all his materials and apparatus, and for all unfinished ditch, levee or other work, and if any of it be damaged, destroyed or lost from any cause, including, among others, floods, wash-outs, or fires, the Contractor shall replace the same at once at his own expense. The Contractor shall be responsible for any unnecessary injury to property.

d. The Contractor must indemnify and save harmless the District or its agents, as provided in the State laws relating to liens. The Contractor shall furnish to the party of the first part satisfactory evidence when called for by it, that all persons who have done work, or who have furnished materials, under this contract, for which he may become liable, have been fully paid or satisfaction secured.

e. The Contractor shall also indemnify and save harmless the District and all those who may be responsible under this contract as the party of the first part, from all suits or actions of every name or description brought against the parties of the first part for or on account of any injuries received or sustained by

any person or persons by or through the Contractor, his servants or agents, in the construction of the work, or by or in consequence of any negligence in doing the work, or by or on account of any act or omission of the Contractor or his agents.

f. The Contractor will be required to hold the party of the first part and the Drainage District harmless against all claims for the use of any patented article, process or appliance used in connection with the contract herein contemplated.

STAKING OUT WORK. a. The Engineer will from time to time set stakes in advance of the work for the center lines and slope lines of the levee and ditches and will furnish the Contractor with the fill for levee and depths and widths of cut for ditches. The Contractor will be held responsible for the preservation of these stakes and for the levee and ditches being constructed in exact accordance therewith.

b. The Contractor when required by the Engineer, shall properly clear the right of way for the levee and ditches for such distance in advance of the work as may be directed, for the purpose of staking out the work.

PAYMENTS. On or about the first day of each month the Engineer will make estimates of the amount of work done during the preceding calendar month (which estimates will be conclusive as a basis to compute the amount the Contractor shall receive for such work), and between the tenth and fifteenth of each month the party of the first part will, for levee fill, pay ....( ) of the value of the work as shown by said estimates. Upon the completion of any entire section of the work, the Engineer will, upon finding the work to be in accordance with the plans,

profiles and specifications therefor, prepare a final estimate of the amount and value of such section, deducting therefrom all previous payments to and charges against the party of the second part, and upon the acceptance of such section by the Engineer and the party of the first part the balance due of the final estimate therefor will be paid.

DESIGNATION. Whenever the words "Drainage District" or "party of the first part" are used in the Notice, Instructions to Bidders, Specification or Contract, they shall be understood to mean and refer to Louisa County Levee District No. 15

and the duly authorized agents thereof; whenever the word "Contractor" occurs in the Specifications and Contract, it shall be understood to mean the party of the second part to such contract. The word "Engineer" as used in the Notice, Instructions to Bidders, Specifications and Contract, shall be understood to mean Jacob A. Harman, of Peoria, Illinois,

or his duly authorized representative acting in his behalf, or his successor if any shall hereafter be appointed by the party of the first part.

RIGHT OF WAY. The party of the first part will furnish land for the construction of the levee and the ditches, and right-of-way along the entire route of levee and ditches, and across farms for passing in and out with supplies, fuel and machinery to prosecute the work.

PROGRESS OF WORK. a. The Contractor shall prosecute the work with such equipment and shall employ such help as shall, in the opinion of the Engineer, be necessary to complete the work

within the contract time. In case the Contractor does not comply with these provisions, the party of the first part shall have the power to employ labor and additional outfit as, in its judgment, may seem necessary to complete the work in the contract time, deducting the total cost of same from moneys due or to become due the Contractor, and in case the cost of the completion of the work shall be greater than the contract price thereof, then the party of the second part shall reimburse the party of the first part for such additional cost.

b. The work shall at all times be conducted by the Contractor in such a manner and with such machinery or other equipment and apparatus as will produce work in conformity with the plans and specifications and to the satisfaction of the Engineer and party of the first part, and whenever the work produced is not acceptable and satisfactory to the Engineer, the Engineer may require the Contractor to follow such methods in handling the work as shall produce satisfactory results, or the Engineer may require the Contractor to furnish such machinery or other equipment as will produce work in accordance with the plans and spedifications.

WORKMEN. a. The Contractor shall either personally superintend his work on the ground, or cause it to be done by some capable representative, who shall be satisfactory to the Engineer.

b. Incompetent or incorrigible persons shall be dismissed by the Contractor or his representative when requested by the Engineer, and such persons shall not again be permitted to return to work without the written consent of the Engineer.

CHANGES. a. "Crossovers" for wagon roads and "banquettes"

for reinforcement of the high fills across sloughs and low places shall be constructed at such places and of such dimensions as the Engineer may direct.

b. The party of the first part reserves the right to increase or diminish the height, width of crown or width of base of levee, and to change its location while in process of construction, and to increase or diminish the depth and width of ditches and change their location while in process of construction, if the material or conditions encountered in the work should, in the opinion of the Engineer, develop the necessity of making changes. The Contractor shall make no claims for damages sustained nor for extra work in connection with such changes but he shall be paid for all work ordered done at the contract price per cubic yard, and when not otherwise directed, all of the work shall be done in accordance with the plans, profiles and specifications.

EXTRAS. a. If any extra work should be required of the Contractor by the party of the first part, such extra work shall be done under the direction of the Engineer at an agreed price or at the actual cost thereof, for labor and material, plus 10% for the use of the Contractor's plant and organization. This provision of the specifications is to cover any additional work which the Engineer may consider necessary, but is not intended to cover any of the required work which is within the intent of these specifications.

b. The Contractor shall file with the Engineer his claims in detail, for extras, monthly and immediately upon the completion of such work.

c. All claims for extras must be filed in writing with the

Engineer before the final estimate is issued for the section in which such extras occur.

CONTRACTOR'S REPORTS. The Contractor shall make written re-reports weekly to the Engineer, showing-

1. The Progress of the Work.
2. The Suspension or Resumption of Work.
3. Any change in method of procedure that he may wish to make.
4. The beginning or completion of any specific work ordered by the Engineer or by the Party of the First Part.

METHOD OF CONSTRUCTING LEVEE.

BASE OF LEVEE. a. The ground to be occupied by the levee must be cleared of logs, trash, weeds and leaves to the satisfaction of the Engineer. Following this the surface between the slope stakes and to a depth of six (6) inches shall be thoroughly broken by plowing or spading, and all trees, stumps and buried logs removed to a distance of not less than 5 feet outside the base of the levee, provided that all such refuse must be burned unless the Contractor shall furnish to the Engineer, in writing, the consent of the owner of land over which the right-of-way is taken to allow such material to remain thereon. Old levee slopes shall be prepared for new fill in same manner.

b. Whenever by reason of delay, rain or other causes, the surface of the ground upon which the levee embankment is to be built, or whenever any part of the levee work shall have been suspended so that the unfinished surface is compacted and will not form a bond with the new material to be placed thereon, such

surface shall be re-broken with plow or spade as above specified.

EXPLORATION TRENCH. An exploration trench shall be dug at or near the center line of the levee when the height of levee is ten feet or more, and wherever required by the Engineer. Said exploration trench shall be about three feet deep and three feet wide at the bottom. After the exploration trench is inspected and measured by the Engineer, it and all other excavations within the base of the levee shall be filled with approved material procured outside the base of the levee. Said material shall be thoroughly compacted while being filled, to the satisfaction of the Engineer, if done by scrapers, wagons or appliances other than some form of excavating machine which drops the material from a height of ten feet or more. All the foregoing work shall be completed at least three hundred feet in advance of the embankment construction. The side slopes in the exploration trench shall be as nearly vertical as practicable, and shall not exceed one foot horizontal to one foot vertical on each side. The Engineer will set stakes and give instructions for the width and depth of the exploration trench and for disposing of the excavated material, within or adjacent to the base of the levee. For all of the material which shall be taken from the exploration trench, payment shall be made for excavation only. In computing the total amount of earth in the finished levee no allowance will be made for the exploration trench wherever the material excavated from the exploration trench has been deposited within the base of the levee, but if the Engineer should require any of the material excavated from the exploration trench to be deposited outside the base of the levee, then an

allowance shall be made for the quantity of material so deposited outside the base of the levee, at the contract price for levee.

CONSTRUCTION. a. When this preparatory work shall have been done, the ambankment construction shall be commenced and unless otherwise authorized by the Engineer, will be started full out to the slope stakes and carried regularly up to gross fill in layers not exceeding two feet in thickness. If the work should be done by steam shovel or other acceptable machinery instead of by teams, the manner of carrying up the fill shall be to the approval of the Engineer. If dredges are used and the material is so soft that it will not stand to the full height at the slope specified, the work may be gone over two or more times to bring the levee to the proper height.

b. The levee shall be built to such height and width that when fully settled it will be of full height required in the plans and profiles, with top width of six (6) feet and slopes toward the river and exterior drainage ditches three (3) horizontal to one (1) vertical, and slopes on inside of two (2) horizontal to one (1) vertical. Allowance for shrinkage must be so disposed on top and slopes as to give the required width of crown, and fill out the slopes to plain surfaces from the edge of crown to base of levee. The allowance required for shrinkage shall be such an amount as the Engineer may direct, but in no case shall the amount required exceed 25 percent. Should the Contractor fail to provide the allowance required for shrinkage during construction, he will be required to bring the levee to full grade and cross section before acceptance. The contents of the levee computed by

the established net grade and slopes only, will be paid for.

c. The alignment of the crown of the levee, when completed, shall not vary from the theoretical location of the crown to exceed five per cent of the base width of the levee at that point, and in no case shall the variation be such as to make abrupt or short bends or reverse curves in the alignment of the crown.

EXTERIOR DITCHES. Wherever exterior drainage ditches are required adjacent to and parallel with the levee, the Engineer will compute the quantity of excavation required for the ditch and the quantity of fill required for the levee for each station of 100 ft. in length, and wherever more excavation is required for the exterior drainage ditch than is required for making the fill of the parallel levee, the ditch will be paid for in accordance with the dimensions required in the plans and profiles at the price per cubic yard for the fill of levee in such station.

SHEET PILING. In any case where there is special danger of seepage, sheet piling shall be driven to such lengths and dimensions as shall be required by the Engineer; said piling to be used to form a core for said levee. The Contractor shall be paid the reasonable cost of providing and placing said piling plus ten per cent of said cost.

MATERIAL BERM AND BORROW PIT. a. Only clean earth, free from trash and roots, shall be placed in the levee. Such earth shall be procured from the river side of said levee as the Engineer may direct; if done by teams no borrow pit shall be made within a zone of twenty (20) feet wide outside of and adjoining the base of the levee. If the work is done by steam shovel or

dredge, a berm twenty (20) feet wide shall be left at the foot of the levee. No material shall be excavated or removed which would "under-cut" the slope of the levee produced. At such places as may be directed, at intervals of about 500 feet, traverses will be left across the borrow pits. Such traverses shall have a bottom width of not less than five times the depth of the adjacent borrow pits and a top width of not less than 10 feet. The Contractor will be required to make such ditches for openings for the drainage of the borrow pits, as the Engineer may direct. For the drainage of the borrow pits the Contractor will be paid by the cubic yard as for exploration trench.

b. No frozen material will be allowed to be deposited in the levee and no levee shall be built or extended upon a frozen surface, except by written consent of the Engineer.

ORDER OF PROCEDURE. The order of procedure of the work shall at all times be subject to the approval of the Engineer.

SPECIFICATIONS FOR OPEN DITCH

INSTRUCTIONS TO BIDDERS:

LOCATION. Map of the locality and plans and profiles of the work may be seen at the office of the Harman Engineering Co., Engineers for said District, at 120 Fredonia Avenue, Peoria, Illinois, at the office of the County Auditor of Des Moines County, Burlington, Iowa and at the office of the County Auditor of Louisa County, Wapello, Iowa.

EXAMINATION OF SITE. Bidders, or their authorized agents, are expected to examine the map, plans and profiles, to visit the locality of the work and to make their own estimates of the facilities and difficulties attending the execution of the proposed work. It is understood that the quantities given are approximate and that no claim shall be made against the Drainage District on account of excess or deficiency in the same.

BINDS AND CONTRACT. a. Bids shall be made out in accordance with the Form of Bid accompanying these specifications and the prices stated in writing and figures. Said bid shall be placed in an envelope, sealed and addressed "Supervisors Louisa-Des Moines Drainage District No. 4" and endorsed "Bid for Drain".

b. Each bid must be accompanied by cash or a certified check in an amount equal to .... per cent of the amount of the bid, enclosed in a separate envelope from that enclosing the bid, and if a certified check the same must be certified without qualification or reservation and drawn on some National Bank or Iowa State bank, said check to be made payable to the

order of the Louisa-Des Moines Drainage District No. 4. The envelope enclosing the cash or certified check shall be addressed plainly upon the outside with the name of the depositor and with the statement, that the envelope contains cash or certified check.

c. The party to whom any contract may be awarded will be required to execute the contract with approved sureties within ten (10) days from the date of notice of the acceptance of the bid. In case of failure or neglect to do so, said party will be considered as having abandoned said bid and the deposit in cash or check will thereby be forfeited to the said Drainage District as liquidated and confessed damages, and thereupon the work may be let to the next lowest bidder or re-advertised and re-let as the party of the first part may determine. The cash or checks of unsuccessful bidders will be returned upon the awarding of the contract on which they have bid and the filing of acceptable bond.

d. The bond to be furnished by the successful bidder shall be personal or Surety Company bond in a sum equal to 25 per cent of the estimated amount of the contract, which bond or bonds shall be conditioned upon the faithful performance of the things specified to be done in these specifications and the contract and subject to the approval of the party of the first part.

e. Bids will not be considered except from parties furnishing evidence, satisfactory to the party of the first part of necessary facilities, ability and pecuniary resources to fulfill and carry out the condition of the specifications and contract.

DESCRIPTION OF WORK. a. The work has been put into .... sections which may be awarded separately or to one or more Contractors, but bids which do not cover all the work in one section

will not be considered. The sections comprise the following work, viz:

....

INFORMATION REQUIRED. Bidders shall state under oath the names and addresses of all persons or Corporations interested financially by pooling or otherwise in their bids ~~of~~ if there be any whose names do not appear upon the bids as submitted. If any bid is made by a Corporation names of the Executive officers and their place of residence shall be given.

COMMENCEMENT AND COMPLETION OF WORK. a. The work shall be commenced within 30 days after the awarding of the contract and completed by December 1st,

b. Bidders who cannot conform to these requirements as to beginning and completion of the work may state in their bids what conditions they would make as to beginning and completion of said work and such bids will be considered and passed upon in the interest of said Drainage District, as the party of the first part in its best judgment may determine.

GENERAL CONDITIONS

GENERAL. A copy of the notice, instructions, conditions and specifications will be attached to the contract and form a part of it. The plans and profiles heretofore approved by the Supervisors will form a part of the specifications.

SUB-CONTRACT. Should the Contractor sub-let any part of the work, he will not be released from any responsibility he may have assumed in executing the contract for this work.

INTERPRETATION. The Contractor will not be allowed to take advantage of any error or omission in the specifications, as full instructions will always be given by the Engineer, should any error or omissions be discovered. The decision of the Engineer, as to quality and quantity of material, work done and workmanship, shall be final.

PENALTY. The party of the second part shall forfeit to the party of the first part, as confessed and liquidated damages, the sum of .... .per day for each and every day that the work or parts of work as herein provided shall remain unfinished, after the day set out for its completion in the Instructions to Bidders.

EXTENSION OF TIME. a. If extraordinary or unforseen conditions supervene which prevent the work being completed within the period stipulated in the contract, the party of the first part may, upon the recommendation of the Engineer, waive the time limit and extend the time for the completion of the work. Should the original time limit be thus waived, all expenses for engineering and inspection and other actual loss and damage to the Drainage District, due to the delay beyond the time originally set for completion, shall be determined by the Engineer and deducted by the party of the first part from any payments due or to become due to the Contractor: Provided, that the party of the first part may remit said charges for so much time as, in its judgment, may be equitable: Provided, further, that nothing in these specifications shall affect the power of the party of the first part to annul the contracts as therein provided.

b. Such extension shall not be granted except upon request in writing by the Contractor to the party of the first part and good cause shown; and no such extension shall be valid unless the same is in writing.

DAMAGES. a. The Contractor shall not be entitled to any damages for any hindrance or delay from any cause whatever in the progress of the work or any portion thereof, as the Contractor, in submitting his bid, takes the chances for the occurrence of such delay; but such hindrance may, in the discretion of the party of the first part, entitle the Contractor to such extension of time for completing the work as may be determined by the Engineer.

b. Under the direction of the Engineer, the Contractor may erect tents, shanties and storage buildings along the line of the ditch, and the Contractor may provide his own lodging camps, properly equipped, at which laborers and teamsters employed by him on the work will be required to lodge unless otherwise directed by the Engineer. It is further understood that whenever dynamite, giant powder or other explosives are to be employed on the work, it shall be handled by persons experienced in its use, and in such manner as to in no way hazard the safety of the men employed about the work, or the safety of the work itself. All explosives shall be stored by themselves at a distance of at least one hundred (100) feet from the work or any structure. The Contractor assumes all liability for accidents due to explosives.

c. The Contractor assumes the responsibility for the safe keeping of all his materials and apparatus, and for all unfinished ditch, levee or other work, and if any of it be damaged, destroyed

or lost, from any cause, including, among others, floods, washouts, or fires, the Contractor shall replace the same at once at his own expense. The Contractor shall be responsible for any unnecessary injury to property.

d. The Contractor must indemnify and save harmless the District or its agents, as provided in the State laws relating to liens. The Contractor shall furnish to the party of the first part satisfactory evidence when called for by it, that all persons who have done work, or who have furnished materials, under this contract, for which he may become liable, have been fully paid, or satisfaction secured.

e. The Contractor shall also indemnify and save harmless the District and all those who may be responsible under this contract as the party of the first part, from all suits or actions of every name or description brought against the parties of the first part for or on account of any injuries received or sustained by any person or persons by or through the Contractor, his servants or agents, in the construction of the work, or by or on account of any act or omission of the Contractor or his agents.

f. The Contractor will be required to hold the party of the first part and the Drainage District harmless against all claims for the use of any patented article, process or appliance used in connection with the contract herein contemplated.

STAKING OUT WORK. a. The Engineer will from time to time set stakes in advance of the work for the center lines and slope lines of the levee and ditches and will furnish the Contractor with the fill for levee and depths and widths of cut for ditches,

The Contractor will be held responsible for the preservation of these stakes and for the levee and ditches being constructed in exact accordance therewith.

b. The Contractor when required by the Engineer, shall properly clear the right of way for the levee and ditches for such distance in advance of the work as may be directed, for the purpose of staking out the work.

PAYMENTS. On or about the first day of each month the Engineer will make estimates of the amount of work done during the preceding calendar month (which estimates will be conclusive as a basis to compute the amount the Contractor shall receive for such work), and between the tenth and fifteenth of each month the party of the first part will, for levee fill, pay .... of the value of the work as shown by said estimates. Whenever any continuous 1000 feet or more of any portion of any section of the levee fill shall have been completed to the established grade and cross-section to the satisfaction of the Engineer, the Engineer shall include with the next regular monthly estimates, after such portion of such work shall have been completed, a sum equal to .... of the value of such completed portion of such section. Between the tenth and fifteenth of each month the party of the first part will, for all other work, pay .... of the value of the work as shown by said estimates. Upon the completion of any entire section of the work, the Engineer will, upon finding the work to be in accordance with the plans, profiles and specifications therefor, prepare a final estimate of the amount and value of such section, deducting therefrom all previous

payments to and charges against the party of the second part, and upon the acceptance of such section by the Engineer and the party of the first part, the balance due of the final estimate therefor will be paid.

DESIGNATION. Whenever the words "Drainage District" or "party of the first part" are used in the Notice, Instructions to Bidders, Specifications or Contract, they shall be understood to mean and refer to the Louisa-DesMoines Drainage District No. 4, and the duly authorized agents thereof, whenever the work "Contractor" occurs in the Specifications and Contract, it shall be understood to mean the party of the second part to such contract. The work "Engineer" as used in the Notice, Instructions to Bidders, Specifications and Contract, shall be understood to mean Jacob A. Harman, of Peoria, Illinois, or his duly authorized representative acting in his behalf, or his successor if any shall hereafter be appointed by the party of the first part.

RIGHT OF WAY. The party of the first part will furnish land for the construction of the levee and the ditches, and right-of-way along the entire route of levee and ditches, and across farms for passing in and out with supplies, fuel and machinery to prosecute the work.

PROGRESS OF WORK. a. The Contractor shall prosecute the work with such equipment and shall employ such help as shall, in the opinion of the Engineer, be necessary to complete the work within the contract time. In case the Contractor does not comply with these provisions, the party of the first part shall have the power to employ labor and additional outfit as, in its judgment,

may seem necessary to complete the work in the contract time, deducting the total cost of same from moneys due or to become due the Contractor, and in case the cost of the completion of the work shall be greater than the contract price thereof, then the party of the second part shall reimburse the party of the first part for such additional cost.

b. The work shall at all times be conducted by the Contractor in such a manner and with such machinery or other equipment and apparatus as will produce work in conformity with the plans and specifications and to the satisfaction of the Engineer and party of the first part, and whenever the work produced is not acceptable and satisfactory to the Engineer, the Engineer may require the Contractor to furnish such machinery or other equipment as will produce work in accordance with the plans and specifications.

WORKMEN. a. The Contractor shall either personally superintend his work on the ground, or cause it to be done by some capable representative, who shall be satisfactory to the Engineer.

b. Incompetent or incorrigible persons shall be dismissed by the Contractor or his representative when requested by the Engineer, and such persons shall not again be permitted to return to work without the written consent of the Engineer.

CHANGES. a. "Cross-overs" for wagon roads and "banquettes" for reinforcement of the high fills across sloughs and low places shall be constructed at such places and of such dimensions as the Engineer may direct.

b. The party of the first part reserves the right to increase or diminish the height, width of crown or width of base of levee, and to change its location while in process of construc-

tion, and to increase or diminish the depth and width of ditches and change their location while in process of construction, if the material or conditions encountered in the work should, in the opinion of the Engineer, develop the necessity of making changes. The Contractor shall make no claims for damages sustained nor for extra work in connection with such changes but he shall be paid for all work ordered done at the contract price per cubic yard, and when not otherwise directed, all of the work shall be done in accordance with the plans, profiles and specifications.

EXTRAS. If any extra work should be required of the Contractor by the party of the first part, such extra work shall be done under the direction of the Engineer at an agreed price or at the actual cost thereof, for labor and material, plus 10% for the use of the Contractor's plant and organization. This provision of the specifications is to cover any additional work which the Engineer may consider necessary, but is not intended to cover any of the required work which is within the intent of these specifications.

CONTRACTOR'S REPORT. The Contractor, when so directed by the Engineer, shall report in writing his progress from time to time, and his plans for beginning and resuming work upon any portion of the contract, the purpose of this being to keep the Engineer informed, so that he may give prompt and proper attention to the details of the work.

METHOD OF CONSTRUCTING DITCHES:

ESTIMATES. Estimates of the quantities for the ditches will be made upon the cross section of the ditches as staked out by the Engineer, and no allowance will be made for excess of width or depth which may be necessarily or accidentally made by reason of the machinery used on the work or for other causes.

CONSTRUCTION. a. The ditches herein provided for shall be constructed with machinery suitable for the work, dug to the depth and bottom width as directed by the Engineer, and have side slopes, as near as may be, of one foot vertical to one (1) horizontal. The excavated material shall be deposited about equally on each side of the ditches, leaving berms of not less than (10) feet in width between the outer slopes of the ditches and the spoil banks.

b. Openings shall be left in the spoil banks for admission of water at intervals of not more than 500 feet on each side of the ditches, also at all depressions where water might accumulate, and at such other places as the Engineer may direct.

c. The timber on the ditch right of way shall be cut and removed therefrom by the Contractor.

SPECIFICATIONS FOR PUMPING PLANTS.

INSTRUCTIONS TO BIDDERS.

7. The pumping plant for which bids are asked will be located on the South side of the Main Ditch in Iowa Slough, where it terminates at the Government Levee, along the West bank of the Mississippi river about three-fourths mile South of the Louisa-Des Moines County line. Oakville, Iowa, on Iowa Central Railroad is about six miles from the site of the pumping station and Keithsburg, Illinois, is across the Mississippi river and about three miles up stream from the pumping station site. The machinery can be transferred from the railroad to barges at Keithsburg, Illinois, and towed to the site of the pumping plant where the barge can be brought along outside of the levee opposite the pumping plant at a distance of about 150 feet.

8. The work to be done by this plant will be the pumping of the water from the ditches of the Drainage District whenever the Mississippi river is too high for proper gravity drainage of the lands for agricultural and sanitary purposes. The aggregate capacity of the pumping plant when operating against the maximum head of 12½ feet (difference in water level) will be 225 cubic feet per second. Under ordinary conditions the pumps will be required to operate against difference of water level of about 7 feet of head, and frequently the head will be 4 feet or less. The plant must be so designed as to be capable of operating economically under these variable conditions. It is anticipated that on an average the plant will be in operation for the equivalent of about 60 full days of 24 hours each during the year, covering a period of about six or seven months. The range from low water to high water in the Drainage District will be

four feet and the range from low water to high water in the Mississippi river into which the pumps will discharge will be 15 feet. Low water in the river and the District assumed at the same elevation, viz: 528 feet above Memphis Datum.

9. The work for which bids are asked will be divided into three parts as follows:

PART I. Furnishing and setting complete ready for operation boiler, boiler feed pump and injector, feed water heater and purifier, steam fittings and piping in the boiler room, pipe covering for same, induced draft apparatus, water gauges, firing tools, etc.

PART II. Furnishing and setting complete ready for operation, engine, condenser, electric light engine and dynamo, steam fittings and pipings within the engine room, covering for the same, wrenches, tools, steam and oil separators, oil pump and oil filter, etc., and furnishing and setting complete ready for operation, centrifugal pumps and pipings for the same, also 12-ton traveling crane for engine and pump room.

PART III. Furnishing all labor and material necessary for the construction of the buildings and the foundations for the buildings, including all of the grading and filling about the pumping station to the grade lines as shown upon the plans and including also the piling for the foundations of the engines and pumps but not including any of the masonry of the foundations for the engines and pumps.

10. Bidders, or their authorized agents, are expected to examine the plans and specifications and visit the locality of the work and make their own estimates of the facilities and

difficulties attending the execution of the proposed work.

11. Bids must be accompanied by cash or certified check in an amount equal to 10 per cent of the amount of the bid. If check, it must be on some National Bank or Iowa State Bank and made out in accordance with the form accompanying these specifications and the price stated in writing and figures. Said bids shall be placed in an envelope and addressed, "Louisa-Des Moines Drainage District No. 4" and endorsed "Bid for Part .. ...." as the case may be.

12. Prior to or at the time of filing bid, the contractors shall furnish detailed lists and descriptions with drawings or photographs to fully explain and describe the style or type of apparatus and fixtures offered, and the construction and finish thereof; if the apparatus offered is known to the trade by a copywrited or trade name, such name shall be given. Said drawings and descriptions of the machinery or apparatus offered to be furnished, must be signed by the manufacturer for identification and when approved by the engineer, will become part of the specifications and contract. Drawings and descriptions will not be made public or shown to competing manufacturers or bidders. The drawings and descriptions of engines on which bids are submitted shall show the clearance space and the bidder shall state the amount of such space in percentage of piston travel.

13. No opportunity will be given for further description of the apparatus or explanation of the same, after the bids have been filed, except as may be required by the Engineer.

14. The bidder to whom the contract may be awarded will be notified in writing by the Engineer and required to execute the contract in quadruplicate with approved surities within ten

(10) days from the date of such notice. In case of failure or neglect to do so, said bidder will be considered as having abandoned said bid and the deposit in cash or check will thereby be forfeited to the said District as liquidated and confessed damages, and thereupon the work may be let to the next lowest bidder or re-advertised and re-let as the Supervisors may determine.

15. The bond to be furnished by the successful bidder shall be personal or Surety Company bond in a sum equal to fifty (50) per cent of the estimated amount of the contract, which bond or bonds shall be conditioned upon the faithful performance of the things required to be done in these specifications and the contract, and subject to the approval of the Supervisors.

16. Bids will not be considered except from parties furnishing evidence, satisfactory to the Engineer, of necessary experience, facilities, ability and pecuniary resources to fulfill and carry out the conditions of the specifications and contract.

17. The work is divided into three (3) parts, which may be awarded separately or to one or more contractors, but bids which do not cover all the work in any one part will not be considered.

18. In awarding the contract, the Supervisors will have in mind the probability of uninterrupted service, the cost of fuel, attendance and repairs, the first cost of the plant, the cost of necessary foundations and adaptability to existing conditions.

19. Each bidder may be required to state the prices of the various accessories which are offered in conjunction with the principal machinery for various parts of the plant, with the

understanding that such accessories may be omitted or changed by order of the Engineer and the Contract price increased or diminished by the amount of the difference in cost of such omissions or changes.

20. Bidders shall state under oath the names and addresses of all persons or corporations interested financially, by pooling or otherwise, in their bid, if there be any whose names do not appear upon the bid as submitted. If the bid is made by a corporation, names of the Executive officers and their places of residence shall also be given.

21. Bidders for Parts I. and II. must be in position to deliver and erect complete ready for operation, all of the machinery and apparatus called for in the specifications for such parts, on or before the first day of March, A. D. 1909, and for Part III. to complete same ready to turn over on or before the first day of January, A. D. 1909.

22. Each bidder must describe, giving the name, weight and approximate dimensions of the largest and heaviest pieces of machinery which it will be necessary to put in place in one piece.

23. Each bidder must state how much of the work or how many parts he is prepared to undertake and complete in the allotted time. Bidders who cannot conform to these requirements as to beginning and completion of the work may state in their bids what conditions they would make as to beginning and completion of said work, and such bids will be considered and passed upon in the interest of said Drainage District, as the Supervisors in their best judgement may determine.

GENERAL CONDITIONS.

24. A copy of the notice, specifications and bid will be attached to the contract and form a part of it and the plans herein referred to together with the detailed drawings and descriptions submitted and approved by the Engineer, will form a part of the plans and specifications.

25. All plans and specifications being the property of the engineer, are to be returned to him. All descriptions and drawings of machinery and apparatus furnished by unsuccessful bidders will be returned to them on their request.

26. Should the Contractor sub-let any part of the work, he will not be released from any responsibility he may have assumed in executing the contract for this work.

27. The Contractor will not be allowed to take advantage of any error or omission in the specifications, as full instructions will always be given by the Engineer, should any error or omission be discovered. The decision of the Engineer, as to quality and quantity of materials and workmanship, shall be final and binding.

28. Unless extraordinary or unforseen conditions surpervene, the time allowed in the specifications, under instructions to bidders, for the completion of the contract is considered sufficient for Contractor having necessary plant, capital and experience. If the rate of progress is not sufficient in the opinion of the Engineer, to complete the work in the time specified herein the Contractor shall furnish such additional help and procure such equipment as the Engineer may direct. In case the Contractor does not comply with the instructions of the Engineer, regarding progress, the Supervisors shall have the right

and authority through the Engineer to employ such labor and additional outfit and procure such materials or appurtenances from other sources, as in their judgment may seem necessary to complete the work in the contract time, and deduct the total cost of expense incurred in such way from any moneys due or to become due the Contractor.

29. If, for any cause, beyond the control of the Contractor, the work should not be completed within the required time in the contract, the Engineer may, with prior sanction of the Supervisors, waive the time limit and permit the Contractor to finish the work within a reasonable time, to be determined by the Engineer. Should the original time limit be thus waived, all expenses for inspection and superintendence and other actual loss and damage to the said Drainage District, due to the delay beyond the time originally set for completion shall be determined by the said Engineer, and deducted from any payments due or to become due to the Contractor; PROVIDED, that the Engineer may, with the prior sanction of the Supervisors, waive for a reasonable period the time limit originally set for completion and remit the charges for expenses of superintendence and inspection for such time as, in the opinion of the Engineer, may actually have been lost on account of unusual freshets, high water, ice, rainfall, or other abnormal force or violence of the elements or other unforseen cause of delay arising through no fault of the Contractor, and which may have prevented him from commencing or completing the work within the period required by the contract; PROVIDED, FURTHER, that nothing in these specifications shall affect the power of the party of the first part to annul the contract as therein provided.

30. The Contractor shall protect and defend the Supervisors and the Drainage District in the full and free use of any and all rights to any inventions or patents used in connection with the contract herein contemplated, against the legal demands of all claimants.

31. All measurements for the setting of the machinery must be made by the Contractor. The Contractor shall set, maintain and protect all templets or patterns necessary for the proper erection of the machinery and appliances furnished by him. The Contractor may superintend the erection and shall be responsible for the correctness of all foundation work for machinery.

32. The Contractor shall put up and maintain such barriers and lights as will prevent accident in consequence of his work and he assumes all liability for damages occasioned in any way on account of the prosecution of such work.

33. Suitable and neat guard rails shall surround fly wheels, cranks or other dangerous parts of the machinery.

34. For all nuts there shall be furnished well made wrenches. Those for finished nuts being furnished marked and all attached to a neat and substantial case which shall be fixed to the wall of the engine room.

35. If any defective or faulty material, workmanship or design of any portion of any of the machinery, apparatus or piping to be furnished under any portion of these specifications should be discovered within one year after the acceptance of the same by the Supervisors, the Contractor furnishing such defective part shall promptly, upon notice from the Engineer, correct such fault and re-place such unsatisfactory portion of such plant at his own expense, PROVIDED that if the Contractor shall fail to

make such changes and repairs under such notice, the Supervisors may make the necessary repairs and collect the cost thereof from said Contractor or his bondsmen if said Contractor shall refuse to reimburse the District for said expense.

36. Whenever the words "Drainage District," "District" or "Supervisors" are used in the Notice, Specifications or Contract they shall be understood to mean and refer to the party of the first part, the Louisa-Des Moines Drainage District No. 4 and the Supervisors thereof; whenever the word "Contractor occurs in the Specifications and Contract, it shall be understood to mean the party of the second part to such contract; whenever the word "Engineer" is used in the Notice, Specifications and Contract, it shall be understood to mean Jacob A. Harman, of Peoria, Illinois, or his duly authorized representative acting in his behalf.

37. The Contractor shall either personally superintend his work on the ground or cause it to be done by some capable representative, who shall be satisfactory to the Engineer.

38. Incompetent or incorrigible persons shall be dismissed by the Contractor or his representative when requested by the Engineer, and such persons shall not again be permitted to return to the work without the written consent of the Engineer.

39. Before the final payment for Parts I and II, the Contractor must furnish and deliver to the Engineer a set of complete general and detailed tracings of all parts of the engine, pumps, boiler and appurtenances, as actually built and installed in the pumping station. The detailed tracings shall show the construction in sectional, outline and plan views, with dimensions written in plain figures and names printed for every detail, indicating the kind of material used and the finish of

the various parts and surfaces. These general and detailed drawings of the finished plant shall be made in sheets on tracing cloth of a uniform size, not larger than 30 inches x42 inches. All sheets shall be uniformly numbered and provided with proper title and headings.

40. Adequate and convenient openings with necessary valves and pipes shall be provided for the quick and thorough drainage of water from every part of every machine or apparatus used in the entire plant to avoid injury from freezing.

41. If any extra work in connection with any portion of the plant should be required of any Contractor by the Engineer, such extra work shall be done under the direction of the Engineer at an agreed price or at the actual cost thereof for labor and material plus 10 percent for the use of the contractors plant and organization. This provision of the specifications is to cover any additional work which the Engineer may consider necessary but not intended to cover any omission of details which are within the intent of these specifications.

42. Any work drawn and not specified or specified and not drawn or particularly mentioned, or any other work necessary to the full completion of the various parts of the plant, according to the spirit and intent of the drawings and specifications, is to be furnished and done by the Contractor for PART under which it will come without extra charge, it being the intention that when the plant is completed in accordance with the contract to be awarded under these specifications, that the same shall be complete in every detail.

43. Any machine or apparatus that will not perform the service required for it in the satisfactory operation of the

plant, or any boiler, engine or pump that fails in capacity or mechanical efficiency as set out in the bids and specifications, shall be removed from the plant by the Contractor whenever ordered by the Engineer and others substituted which will comply with such requirements. The Contractor and his bondsmen shall not be discharged until such condition shall have been complied with.

44. Drawings showing general arrangement and dimensions of machinery and foundations, piping and apparatus to be furnished by each Contractor must be prepared by him and submitted to the Engineer for his approval within (30) thirty days after the awarding of the contract. The plans for the building will be changed in such detail as may be necessary to best and most economically accommodate the machinery and apparatus for which contracts may be awarded. The plans now prepared being for the purpose of indicating the arrangement which will be followed and the dimensions, as near as practicable, which will be necessary for the proper housing of the plant.

45. As early as practicable after the general plans have been approved by the Engineer, the Contractor shall furnish detailed drawings showing complete sectional outline and plan views giving all necessary dimensions and shall definitely state in printed letters at all surfaces and details the name of the parts and the machine work and finish to be put on them. There shall also be separate detailed drawings of such features as are not clearly shown by plan and section.

46. All drawings shall be furnished to the Engineer in triplicate. One copy to be returned to the Contractor after approval, one copy for the office and one copy to be placed in

the hands of the inspector upon the work.

47. Tests for capacity and efficiency shall be made by the Engineer as early as practicable after the completion of the plant and not later than June 30th, A. D. 1909, PROVIDED, that if the plant be not completed in time for such tests to be made prior to the above date, then such tests shall be made at the first favorable opportunity. The Contractor shall furnish all of the labor, piping, fittings and apparatus required by the Engineer as necessary for the tests and may have an acceptable expert representative present to assist. The instruments shall be calibrated and the tests made under the direction of the Engineer.

PART I. - BOILERS AND APPURTENANCES.

48. The boiler plant will consist of the following: one high pressure water tube boiler together with its foundations, settings, shaking and dumping grates, fittings, firing tools and turbine cleaner, etc., complete and ready for operation; one 10 H.P. vertical fire tube boiler for a working pressure of 100 lbs.; one duplex double acting outside-packed-plunger steam pump having capacity of not less than 28 gallons per minute, when operating at a piston speed not to exceed 40 feet per minute; one steam injector having capacity to supply the 300 H.P. boiler; one open feed water heater and purifier and automatically controlled steam water supply pump with capacity to supply 1,600 gallons of water per hour and raise the temperature from 60 degrees to 212 degrees Fahrenheit; steam fittings, valves and piping for connecting the boilers and delivering the steam to a point 3 feet inside the engine room wall; the covering for steam pipe and steam fittings

and painting for same; the necessary breeching and steel chimney and suction fan for induced draft, fan to be direct connected to slide valve automatically controlled steam engine, and shall have a capacity sufficient to furnish ample draft to operate the boiler when using Illinois or Iowa bituminous coal screenings and developing 60 per cent more than rated H. P., one 12-inch Crosby illuminated dial steam guage registering 0 pounds-250 pounds, and standard water guages and columns with safety alarms; one Bristol pressure recording steam guage.

49. The boiler must have at least 3,000 sq. ft. of water heating surface and have a rated capacity of 300 boiler H.P., based upon an equivalent evaporation of 34.5 pounds of water from and at 212 degrees Fahrenheit per boiler H.P.

50. The boiler shall be made absolutely tight under a hydrostatic pressure test of 240 pounds per sq. in. The working steam pressure will be 160 pounds per sq. in. by guage. Certificate of inspection and boiler insurance for one year by Hartford, or some other acceptable boiler insurance company, shall be furnished by contractor.

51. The boiler is to be located as shown upon plans.

52. All material and labor are to be first-class of their respective kinds. The boiler is to be supported independent of the walls, free to expand or contract without affecting the same, and so that the brick work may be removed and replaced without disturbing the boiler or connections.

53. The boiler is to be delivered and erected ready for operation in the boiler room of the pumping station on foundations to be furnished by this contractor. If foundation is required to greater depth than thirty inches below the floor line, such ad-

ditional depth will be provided at the expense of the District.

54. Detailed plans for the piping of the boiler house shall be prepared by the Contractor and submitted to the Engineer for approval before proceeding with the erection of the same. Such piping shall be so arranged that the exhaust steam from the engines and pumps, excepting the condensing engine, shall be connected to the feed water heater and by-passed to the open air; piping for the vertical fire tube boiler shall be so arranged that steam can be supplied to the induced draft engine, to the electric light engine, to the boiler feed pump, to the boiler cleaning apparatus and to the water supply pump without admitting steam into the main steam pipe between the main boiler and the engine. Provision shall be made under the direction of the Engineer for supplying steam below the fire grates. Where directed by the Engineer, openings shall be left in the steam line in the boiler room for additional steam connections that may be needed and at such places as may be convenient for taking samples and the temperature of the steam. The piping for suction for feed water heater, shall be so arranged that the water may be taken from the ditch channel and the condenser well, as the operating conditions may require, and the boiler feed pump shall be so piped as to permit of taking of water from the heater and from both or either of the above sources.

55. Bidders shall state the amount which may be deducted from their bids if induced draft apparatus should be omitted, and price for reinforced concrete chimney, if substituted.

56. The induced draft engine shall have regulating valve controlled by the steam pressure in the boiler so that whenever the pressure passes the desired point, the draft will be reduced

and thereby control the fire. The regulating valve to be selected subject to the approval of the Engineer.

57. It is the intention that these specifications for PART I and the general conditions shall include, besides the principal apparatus herein described, all of the necessary accessories, whether described or not, for the complete installation of a modern boiler plant and appurtenances, whether the same shall be located in the boiler room or the engine room, for the delivery of dry steam at a working pressure of not less than 155 pounds in the main pipe leading into the engine room.

PART II.- ENGINES AND APPURTENANCES.

58. PART II will consist of furnishing and erecting the following, viz:-(1) one 500-I H. P. horizontal tandem compound, condensing, Corliss or "four-valve" engine direct connected to two centrifugal pumps, on the engine shaft extended, all on foundations to be furnished by this contractor; (2) one electric light plant, wiring and lights as shown including 4 H.P. automatic cut-off engine, 2 K. W. generator for producing electric current at 110 volts, for lighting the plant. With said engine and generator shall be included all necessary oil cups, wrenches, pulleys, rheostat for regulating voltage and volt meter; (3) steam and oil separator; (4) barometric condenser and supply pump, independently operated; (5) a speed counter on engine and all necessary and usual valves, steam pipings and fittings and appurtenances, including the covering of the steam pipes within the engine room and from a point where the steam pipe is left by Contractor for the boilers and the painting of the same; (6)

wrenches, tools; (7) oil filter pump and a piping system to deliver oil to the bearings of the engine pump.

59. Engine shall develop not less than 500 I.H.P. with piston speed not exceeding 600 feet per minute, at one-fourth cut-off with a maintained gauge pressure of 150 pounds at the throttle. Normal speed shall be about 150 R.P.M. The engine shall be capable of developing 125 per cent of normal rating at the above specified throttle pressure and piston speed.

60. The friction load of engine shall not exceed 8 per cent of rated full load I.H.P.

61. The fly-wheel shall be of neat design and have a factor of safety of at least ten (10). The rim of the fly-wheel shall be accurately turned on both sides. The main shaft of the engine shall be extended to operate the two 48-inch pumps. The farther pump shall be provided with friction clutch or shaft.

62. The governor shall be constructed that the speed of the engine may be changed, while running, through a range of from normal speed to 60 per cent of the normal speed. If any engine is offered on which it is not practicable to change the speed without shutting down, a full explanation of this fact and the method of changing the speed shall be given.

63. Contractor shall state the pounds of dry steam at 150 pounds guage pressure at the throttle, with which he will guarantee the engine to develop one I.H.P. hour when operating with 26 inches vacuum at normal speed, with the following loads, viz: (1) 25 per cent over load, (2) normal load, (3) 75 per cent load, (4) 50 per cent load, (5) 25 per cent load. The contractor shall state the range of load and what benefit, if any, may be secured by operating engine with variable steam pressure, variable

speed or both with low head of water to pump against.

64. The engine shall be of standard modern design and best quality of material and workmanship throughout. As the engine will be out of service for a considerable portion of each year, it is desirable to have all exposed parts of the engine, which are not in contact with some moving part, painted.

65. All working parts of the engine are to be made to guage and interchangeable.

66. The Contractor shall, at his own expense, furnish an expert who shall have charge of the erection of the engine and appurtenances called for in Part II of these specifications and who shall under direction of the Engineer be in charge of the plant and operate the same for at least 30 days after the completion thereof, at such a time as may be practicable to have the same in operation under load conditions. This expert shall instruct the purchaser's operating engineers in the care and operation of the plant.

67. In the construction of the foundations, if the soil should be soft or of such a nature as to be unsafe, piling will be placed under said foundations in accordance with the plans. Such piling shall be furnished and driven by the Contractor for Part III.

68. Engine shall be provided with an exhaust to the atmosphere and an exhaust opening of approved type.

CENTRIFUGAL PUMPS.

69. The contract for this portion of Part II will include furnishing and setting on foundations furnished by this Contractor two 48-inch centrifugal pumps, direct connected to engine as herein above required, suction and discharge pipes as

shown on plans, one vacum pump or power exhauster operated by independent steam engine for priming the main pumps.

70. These pumps shall have a combined capacity of not less than 225 cu. ft. per second when working against a head of 12½ feet between the level of the water in the main channel and the discharge channel.

71. The arrangement of the pumps, the suction pipes and discharge pipes is shown upon the plans. Man holes shall be located as shown on discharge pipes. The foundation for the pumps are to be furnished by the Contractor for Part II but in case the ground is soft or yielding, and, in the opinion of the Engineer, it should be necessary to use piling, such piling will be furnished and driven by the Contractor for Part III.

72. In making the plans for the foundations for setting the pumps, it will be necessary for the manufacturer to take into consideration the character of the soil and submit plans to Engineer which shall meet his approval before proceeding with same.

73. Arrangement for priming the pumps will be made by connecting the vacum pump, with the crown of each of the pumps. The Contractor for the pumps being required to furnish and install the necessary piping and valves for connecting the pumps and the exhauster. An opening to the air with valve not less than four inches in diameter shall be provided at the crown of each pump for admitting air to break the vacuum whenever necessary.

74. The Contractor shall state the guaranteed capacity and mechanical efficiency of pumps when working under the following conditions, viz: at normal speed (which shall be stated), 25 per cent above normal; 75 per cent of normal and 50 per cent

of normal speed against working head of 5 ft., 7.5 ft., 10 ft., 12.5 ft., and 15 ft. respectively. Such efficiency shall not be less than 75 per cent for pump and piping when working against a ten-foot head.

SPECIFICATIONS FOR STEAM PIPE FITTINGS AND PIPING TO BE DONE UNDER PART I AND PART II.

75. All valves $\frac{1}{2}$ inch in diameter or over supplied by the Contractor shall be gate valves. Those 3 inches in diameter or over shall be iron body valves and all valves less than three inches in diameter brass body valves, (Scott or Atwood gate valves approved.)

76. All flanges and steam pipes are to be packed with corrugated copper gaskets, the steam valve stems are to be packed with asbestos wick, soaked in oil.

77. All pipe lines when finished must be clean and free from all obstructions, dirt and iron cuttings.

78. All pipe lines are to be tested after erection by applying 200 pounds water pressure and under this pressure all joints must be tight. No caulking of joints will be allowed but defective or leaky joints must be made tight by screwing tight. This test must be made by the Contractor in the presence and under the direction of the Engineer.

79. The work of piping must be performed at such times as set by the Engineer.

SPECIFICATIONS FOR COVERING OF STEAM PIPES REQUIRED IN PART I AND PART II.

80. Contractors shall submit prices for using such material as they may deem best adapted for covering the pipes, valves, etc., required for this work in a first-class and workmanlike manner. Durability as well as insulating properties desired. Only first class material and work will be considered. All piping and fittings carrying live steam are to be covered.

81. Samples of covering on which bids are made shall be submitted to the Engineer. All pipe covering is to be painted with two coats of paint of approved color.

PART III. - BUILDING, FOUNDATIONS, PILING.

82. These specifications for Part III are intended to cover and provide for the completion of all of the work described in the general and detail plans and all general provisions in these specifications shall apply so far as practicable. The work is to be constructed and finished in every part in a good, substantial and workmanlike manner, according to these specifications and accompanying drawings, to the full intent and meaning, expressed or implied, of the same and to the entire approval and acceptance of the Engineer.

83. All materials to be the best of their specified kinds and all workmanship to be of the best quality. The Engineer is to have full power to reject any materials or workmanship which do not conform to these specifications, and to cause the same to be immediately removed or reconstructed by the Contractor without any additional cost to the owners.

84. On completion of the work, each Contractor shall remove all rubbish and surplus material from the premises and

shall leave all of his work in a completed and cleaned up state without exception.

85. Where details are given they must be accurately followed. In all instances, figured dimensions must be used in preference to the scale dimensions, but where figures are not given the drawings are to be carefully studied. The drawings and these specifications are intended to be co-operative, and anything shown in one but not the other is to be constructed and finished as carefully as if it were plainly shown in both.

86. Each Contractor is to protect his work and materials, whether placed in the building or not, from wind, water, heat, or frost, or other elements that may tend to interfere with the stability and perfection of the work, and he will be held responsible for all damage or expense resulting from his neglect of this care.

87. No Contractor is to take advantage of any manifest omission or discrepancy that may be found to exist between plans and specifications, but all such omissions or errors shall be reported to the Engineers for corrections as soon as they are discovered. All differences or disagreements as to sizes, materials or workmanship shall be referred to the Engineers, whose decision on their plans and specifications is to be final and binding upon all parties as the true intent and meaning thereof.

88. Plans and specifications are the property of the Engineer and are to be used for this building only. All copies of the same must be gathered together and given over into the hands of the Engineer before final settlement for the job is asked.

89. The Contractor for the mason work is to be gov-

erned by the general clauses and conditions, numbered 82 to 88 inclusive, of these specifications, to which he is referred and which will become a part of his contract. The mason must provide all labor, transportation, materials, apparatus, scaffolding and utensils, necessary for the complete and substantial erection of all work coming under his contract; he must carefully lay out the building, according to the lines and levels given him by the Engineer, and is to be responsible for any mistakes he may make, and any injury to others resulting from them.

90. The approximate present grade of the ground is shown on the elevations by the present grade lines. All excavation earth is to remain on the premises and must be graded off inside the building up to the proper height to receive the concrete floor and this filling must be wetted down and tamped in solid so that it will not settle. All remaining excavated earth is to be filled in around the outside of the building and placed as directed by the Engineer. Excavate to the depth and width shown on the drawings for all walls, piers, retaining walls, etc., and for all pumps and engine beds to the depth directed by the Engineer.

91.This Contractor is to do all necessary filling in around the building up to the finished grade lines shown on the elevations, and is to do all necessary grading off of the earth to the slopes indicated on the plans.

92. This Contractor is to furnish and drive all piles shown on the foundation plan. All piles under the pumps, engines and foundation walls shall be 20 ft. 0 inches long and shall be of sound pin oak or other available local timber satisfactory to the Engineer. The round piling must be at least 8

inches in diameter at the point, must be reasonably straight, trimmed close and have the bark stripped off before they are driven. They must be spaced as required by the drawings, driven vertically, and when necessary bound with iron hoops to prevent brooming. All piles, after being driven to the proper depth, shall be sawed off square and horizontal at the grade required for the concrete footings of the building and at the height directed by the Engineer for the engines and pumps. All sheet filling piling required for the support of suction pipes is to be tripple layer 3-inch piling solidly spiked together, 12 ft. 0 in. long and driven to the proper depth and reinforced with round piles as shown.

93. All footings for the walls of the building are to be built up of concrete in the following manner. Build wooden forms of the right size of smoothly dressed planks securely fastened so that they cannot spring out of place when the concrete is tamped in. These forms must remain in place until the concrete is firmly set. The concrete is to consist of "Atlas," "Chicago AA," or some other brand of Portland cement equally satisfactory to the Engineer, clean sharp sand, and clean gravel or screened broken stone mixed in the proportions of 1, 2½ and 5 parts by measure. The ingredients are to be thoroughly mixed before being wetted, immediately deposited and solidly tamped into the wooden forms until it is settled firmly in its place. The footings are to be made of the width and depth shown on the drawings and must extend down over the ends of the piles at least one foor foot.

94. This Contractor is to build a coffer-dam of sufficient size around the outlet of the discharge pipe and after

all water has been pumped out he is to build wooden forms for the retaining wall of the size shown on the drawings. Concrete in the same proportions as specified above for footings is to be deposited in these forms in layers of not over 1 ft. 0 inches deep and the top surface is wetted before another layer is deposited. Use smoothly dressed oiled planks for the forms above low water mark and grade and plaster the inside as the concrete is deposited with Portland cement mixed with three parts of clean sharp sand. In all concrete work this Contractor is to co-operate with other Contractors furnishing machinery and pipes and is to embed all discharge and suction pipes in concrete as directed by the Engineer. All cast concrete work for the support of the suction pipes is to be made in the same manner as described above and of the size shown on the drawings.

95. All walls of the building above the foundation are to be built up 12 inches thick, of hollow concrete blocks in 8-inch courses. The blocks are to be made in the usual manner of "Chicago AA," "Atlas" or some other equally satisfactory Portland cement, sand and gravel in the proportions of at least 1 part cement to 2 parts sand and 4 parts gravel or crushed stone. The stone are to be smooth faced both inside and outside except the quoins which are to be rock faced and all are to be set on a full and even bed of mortar composed of 1 part "Utica" or some other equally satisfactory hydraulic cement to 2 parts of clean sharp sand. Mortar must not be used after the cement in it has begun to set. Joints should not be over $\frac{1}{4}$-inch thick and must be properly struck both inside and outside. Care must be taken to properly bond all wall blocks into the pilasters and buttresses shown. All blocks must be of uniform thickness and smooth on

both sides without any of the coarser gravel or crushed rock showing through. They must be made in the moulds face down and have $\frac{1}{2}$inch of mortar face composed of 1 part cement $1\frac{1}{2}$ parts sand. The front wall of the building from the footing up to the grade line is to be battered on the outside as shown on the drawings and is to be cast of solid concrete in the same manner as specified above for the retaining wall. The inside of the wooden form for this wall, before the concrete is deposited, is to be covered with water proof building paper put on as smoothly as possible, and after the wall has set it is to be removed with the forms, and all defects in the wall repaired so as to present a smooth, uniform surface. The supporting pilasters for the iron beam of the traveling crane are to be capped with a single solid concrete block 16 inches deep, which must be cast in its proper place and have the necessary $\frac{3}{4}$-inch iron bolts imbedded into it to receive the iron plate and beam. These cap blocks must extend through and be bonded into the wall. The ends of all I beams will have $\frac{3}{4}$-inch cross bar anchors 2 ft. 0 inches long and the blocks coming at the ends of these beams must be cast solid in its place, thus imbedding the anchor and end of the beam.

96. All window sills, copings, belts and panels used in the building are to be made in the proportions of 1 part Portland cement, 2 parts sand and 4 parts gravel. The outside wearing surface to be a $\frac{3}{4}$-inch layer of 1 part Portland cement to $1\frac{1}{2}$ parts sand. The coping for the outside walls is to be 5 inches thick and the window sills are to be 8 inches thick, and all to be cast with proper drip. The sills are also to be cast with a wash. They are to project 1 inch beyond the face of the

wall and the sills are to extend 4 inches into the wall each side of the opening. All caps for windows and doors are to be reinforced with ½-inch iron rods as sirected by the Engineer.

97. The name plate as shown on the front elevation is to be cast in cement the full thickness of the wall and in sections not over 6 ft. 0 inches long. The border is to be 3 inches wide, project 1$\frac{7}{4}$ inch and neatly moulded and the letters are to be plain block letters recessed at least 1 inch. The ornamental blocks shown at each side of the central projection are to be made in a similar manner.

98. The entire building, except under the pumps, boilers and engines is to have a concrete floor constructed as follows: On a 3-inch layer of cinders or coarse gravel well tamped down, place 5½ inch layer of concrete composed of 1 part of "Atlas" or other equally satisfactory Portland cement to 2½ parts of sand and 5 parts of course gravel. Tamp this layer off true and even and immediately put on a ½-inch wearing layer composed of 1 part Portland cement to 1½ parts of clean fine sand. Trowel the surface of this wearing layer off smooth and divide into squares of convenient size to prevent cracking. The outlet bay as shown on the foundation plan is to be paved with concrete as specified above for floors, except that the cinders and top coat are to be omitted and the concrete made 12 inches thick.

STRUCTURAL IRON AND STEEL.

99. The Contractor for the iron and steel work is to be governed by the general clauses and conditions in paragraphs

82 to 88 inclusive of these specifications to which he is referred and which will become a part of his contract.

100. The Contractor will furnish all iron work required by the plans and specifications and is to furnish the same promptly, as required so as not to delay the work. All steel shapes used must be made from stock that has been tested and has shown an ultimate tensile strength of 60,000 pounds per sq. in., and the shapes must be strictly No. 1 in every respect and uninjured by the handling they have received. All steel and iron work must be brought to the job having one coat of red oxide of iron ground in pure boiled linseed oil, and as soon as it is in place, the contractor for this work must give all another coat of the same kind of paint.

101. Furnish all necessary steel bearing plates as indicated on the plans.

102. All beams for this job must be first quality, free from kinks or other injury, and all punching must be clean and sharp and at the right point so bolts can be entered without driving.

103. Every 4th wooden rafter will be anchored to the concrete walls by 1/8 inch by 1¼ inch strap joist anchors with ½-inch cross bar 8 inches long. Where joists come parallel to wall furnish anchors of the same kind except that they are to be 4 ft. 0 in. long. The steel beams resting on iron plates in the walls are to have ¾-inch rods 2 ft. 0 in. long passed through their ends to anchor them to the concrete work, and the beams supporting the track for the crane are to be securely bolted down through the bearing plates to the concrete pilaster with ¾-inch bolts 16 inches long.

104. All windows of the building are to be covered on the outside by window guards made from No. 12 crimped galvanized wire in 1-inch square mesh, and channel iron frames, securely fastened in place, with expansion bolts. These frames must be galvanized before being put in place. The measurements for all wire guards must be taken at the building and the frames made to snugly fit the openings.

CARPENTER WORK.

105. The Contractor for the carpenter work is to be governed by the general clauses and conditions in paragraphs 82 to 88 inclusive of these specifications to which he is referred and which will become a part of his contract.

106. The carpenter is to do all the necessary woodwork, all of the cutting, etc., of woodwork for all of the other workmen. He shall furnish temporary protection to all openings, and shall deliver up the work when finished in a perfect and undamaged state without exception.

107. All framing timber used throughout the building is to be long leaf southern pine. It must be sawed die square, and must be free from large or loose knots, blue sap, wind shakes, or other imperfections impairing its durability or strength. All must be fitted and fastened in a first class manner. The end of every fourth rafter is to be anchored into the concrete walls and at the sides of the building where the joists run parallel to the wall, put an anchor 4 ft. 0 in. long, every 5 ft. 0 in. All anchors will be furnished by the Contractor for the iron work. All rafters are to be bridged with a

row of double cross bridging spaced midway between supports. This bridging is to be made of 1-in.x3-in. stuff accurately fitted and firmly nailed at both ends with 10d nails. All bridging shall be made of white pine, the top ends shall be nailed before sheathing is laid, and the bottom ends shall be nailed after sheathing has been laid.

108. The entire roof is to be sheathed with No.2, D. & M. 5¼-in. fencing laid diagonally at an angle of 45 degrees and closely driven together and nailed through with two 8d nails to every bearing. All ends of joists must be sawed over a bearing and all loose or black knots must be sawed out so that this sheathing will form a firm bearing for the gravel roof.

109. All window frames are to be made from selected soft yellow pine and are to be the regular box frames for masonry walls and 1¾-inch check rail sliding sash. The outside hanging stiles and subsills are to be 1¾-inch blind stops and pulley stiles 7/8-inch and the pulley stiles fitted with Gardner or other equally good turned sash pulleys.

110. The frames for all doors including the coal doors, are to be made of 3-in.x10-in. plank. All of these door frames are to have 2-in.x4-in. strips spiked around them for holding them firmly in the wall.

111. All sash are to be No. 1 white pine or cypress sash 1¾ inches thick and glazed with "A" double strength glass, and all are to be balanced by iron weights with 5-16 "Samson Spot" or "Silver Lake A" sash cord.

112. All doors are to be made by the carpenters as follows: First make a frame of the stiles and rails as indicated on elevations for outside of door out of 7/8-inch stuff,

then cover it all over with 7/8-inch or ¾-inch double faced, beaded, soft yellow pine ceiling laid diagonally in the direction shown on the elevations, place on top of this another frame of stiles and rails exactly like the one in under, and firmly nail all together, and trim the edges square and true. Fit all the angles of the panels with ¾-inch quarter round.

113. This Contractor is to furnish and put on all hardware. The catalogue number specified are from Russell & Erwin's catalogue, but goods of any other make may be used, provided they are of the same general design, quality and finish as the numbers specified. Any hardware not especially mentioned is to be furnished of a design and quality in keeping with that specified.

114. Each sliding window is to be balanced by iron weights with 5/16-inch "Silver Lake A" or "Samson Spot" sash cord, and is to be furnished with one lift No. 7155 and one lock No. 7121.

115. Hang the coal doors and rear door to the boiler and coal room on three heavy T hinges, and furnish with heavy hasp and staple and thumb latch.

116. Hang the sliding doors on Allith, McCabe or some other equally satisfactory barn door hanger. The tracks for these hangers must be securely fastened to the concrete walls with expansion bolts, and each sliding door fitted with a heavy hasp and staple for locking with a pad-lock.

TINNING AND ROOFING.

117. The Contractor for this work is to be governed

by the general clauses and conditions in paragraphs 82 to 88 inclusive of these specifications, to which he is referred, and which will become a part of his contract.

118. Across the back end of the building, place a 6-in.x8-in. hanging gutter of No. 28 galvanized iron strengthened by a roll rim and galvanized wire hanger every 3 ft. 0 in.

119. Where indicated on the rear elevation, place two 5-inch corrugated iron down spouts. These spouts must be firmly fastened to the concrete wall by galvanized iron hooks, must have all of its joists properly lapped and soldered together, and must end in an elbow 6 inches from the ground, turned away from the building.

120. The roof is to be covered with a 5-ply wool felt, composition and gravel roof. The felt must be of the best quality, must weigh at least 15 pounds to the square for each thickness, must be well cemented the full width of the lap with the best quality of roofing cement, using not less than 100 pounds of roofing cement to the square of 100 square feet. All joinings around the walls must be properly made with the felt turned up at least 8 inches and the whole finished with two coats of the cement and screened gravel, free from dirt and clay.

121. The composition roofing must not come nearer than 2 ft. 0 inches from the smoke stack and the tinner is to make a sheet iron collar which is to be well finished into the composition roofing and extend up along the stack at least 8 inches. The counter flashing will be furnished by Contractor for Part I.

122. This Contractor is to furnish and properly set and flash into the composition roofing two 24-inch and two 36-inch Lee or other satisfactory ventilator with dampers. The

two 24-inch ventilators are to be set over the pump room and the two 36-inch ones over the boiler room as directed by the Engineer.

PAINTING.

123. The Contractor for the painting is to be governed by the general clauses and conditions in paragraphs 82 to 88 inclusive of these specifications to which he is referred and which will become a part of his contract.

124. Cover all pitch, knots etc., of wood to be painted, with a coat of shellac before priming; putty up all nail heads and other defects in all woodwork and clean off all paint, spots from glass and walls at completion of the work.

125. All exposed woodwork of the doors and windows of the building, both inside and outside, is to be primed as soon as possible after it is brought to the job with white lead in pure boiled linseed oil. After priming it is all to receive two more coats of white lead and pure boiled linseed oil, tinted in color as directed by the Engineer.

126. All galvanized iron gutters and down spouts are to be given two coats of Venetian red and linseed oil.

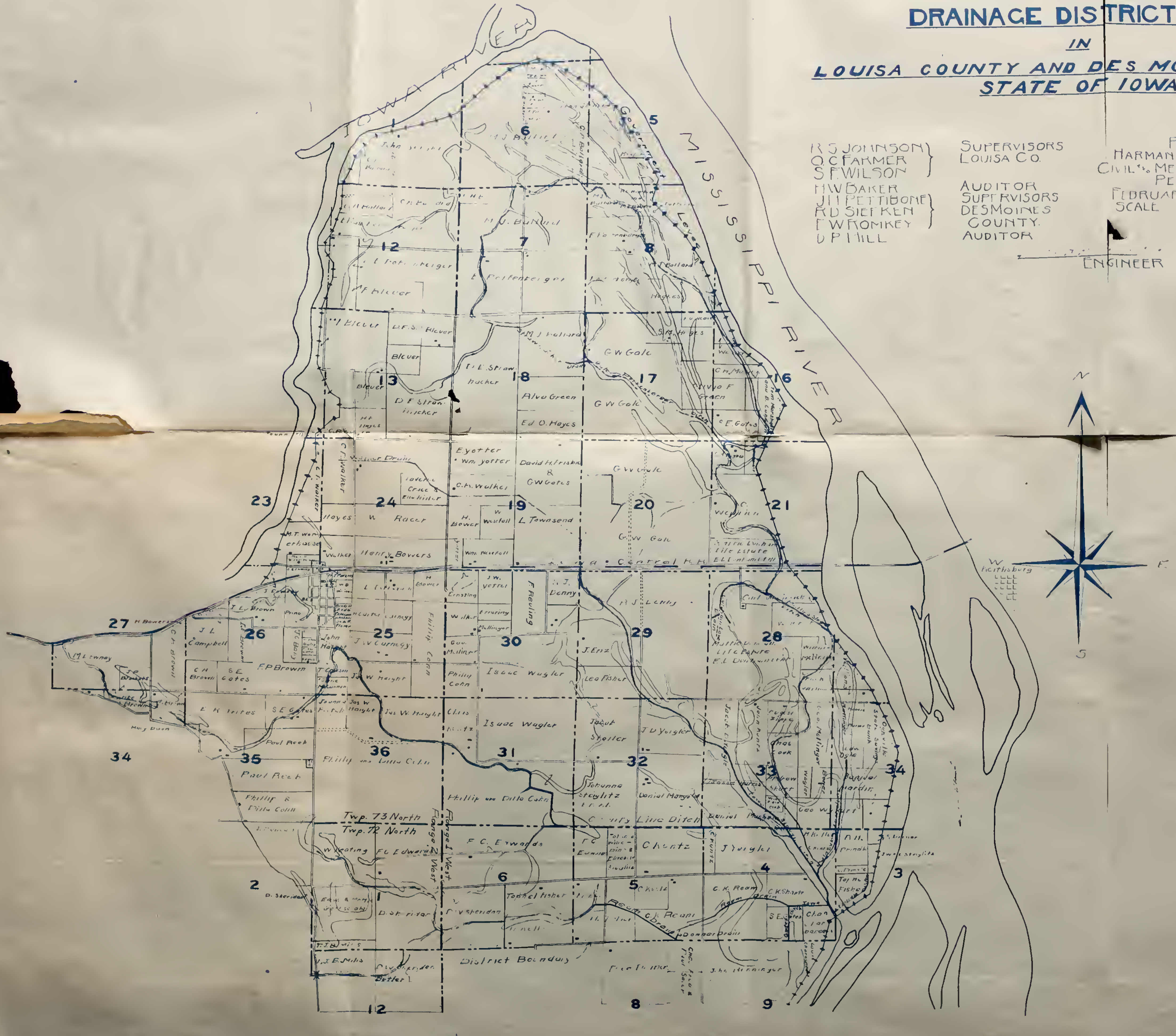
ILLUSTRATIONS.

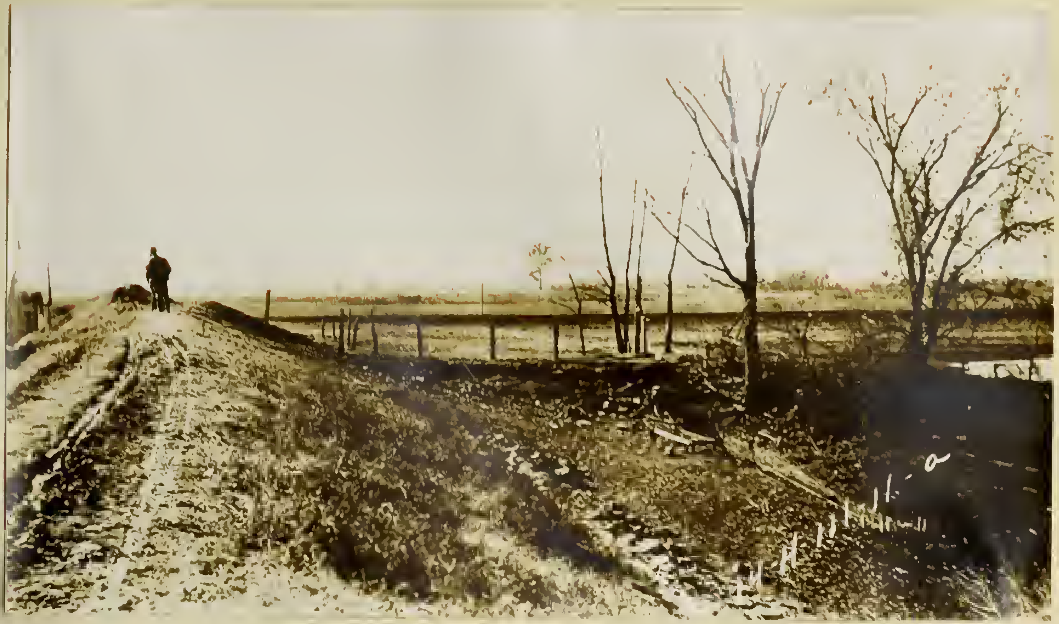
LOUISA-DES MOINES
DRAINAGE DISTRICT NO 4
IN
LOUISA COUNTY AND DES MOINES COUNTY
STATE OF IOWA

R S JOHNSON O C FARMER S F WILSON	SUPERVISORS LOUISA CO.
H W BAKER	AUDITOR
J H PETTIBONE R D SIEFKEN F W ROMKEY	SUPERVISORS DES MOINES COUNTY.
D P HILL	AUDITOR

PREPARED BY
HARMAN ENGINEERING CO
CIVIL & MECHANICAL ENGINEERS
PEORIA ILLINOIS
FEBRUARY 1910
SCALE 2500 FT 1 INCH

ENGINEER





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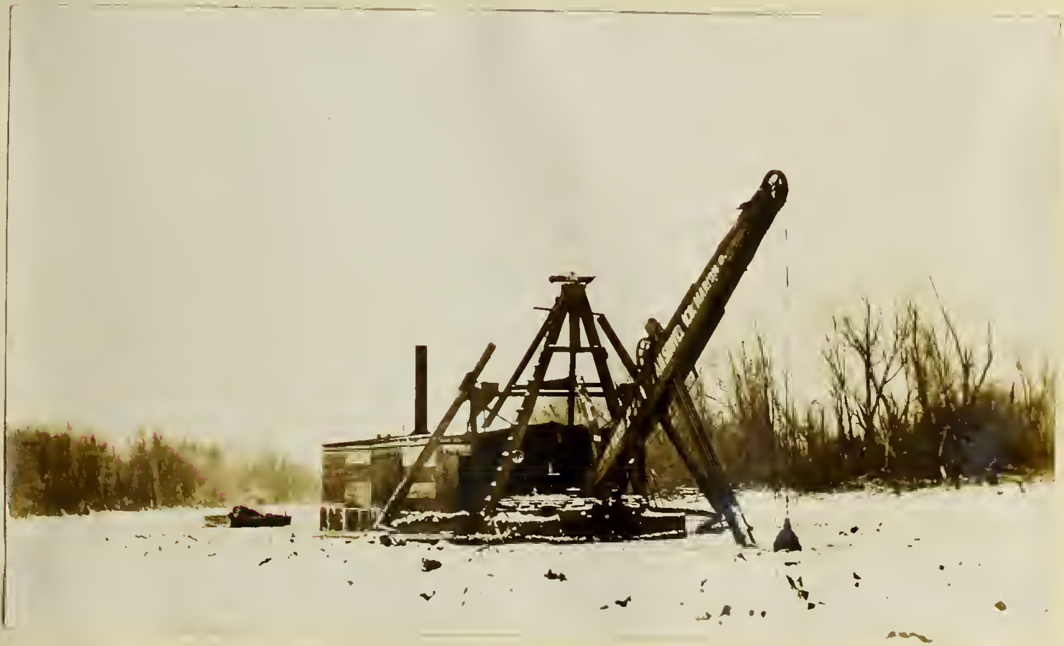

DREDGING DITCH.

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BOILERS

BOILERS.

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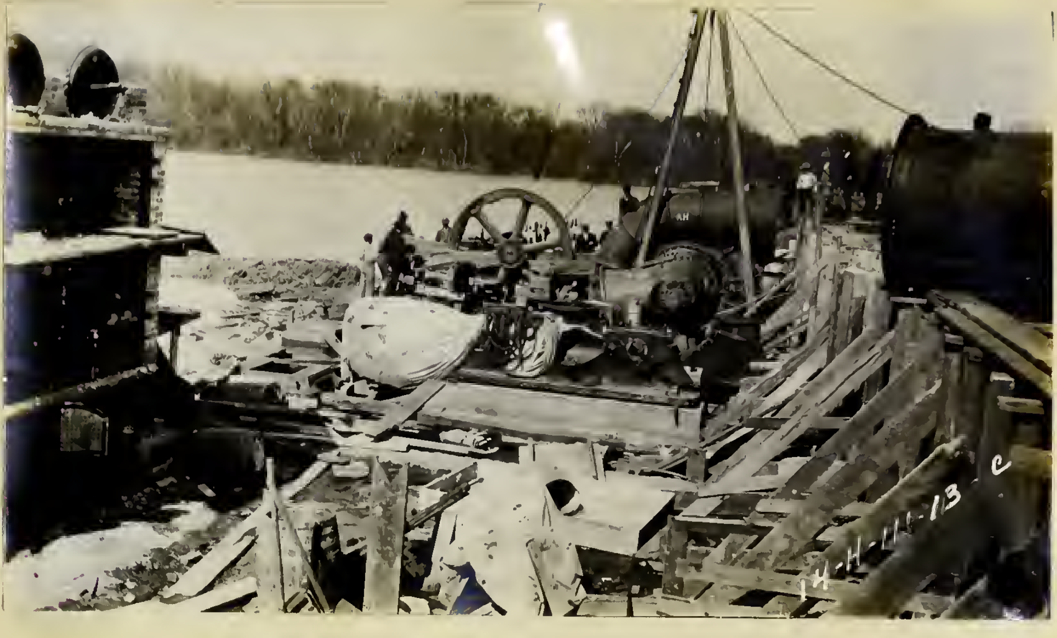

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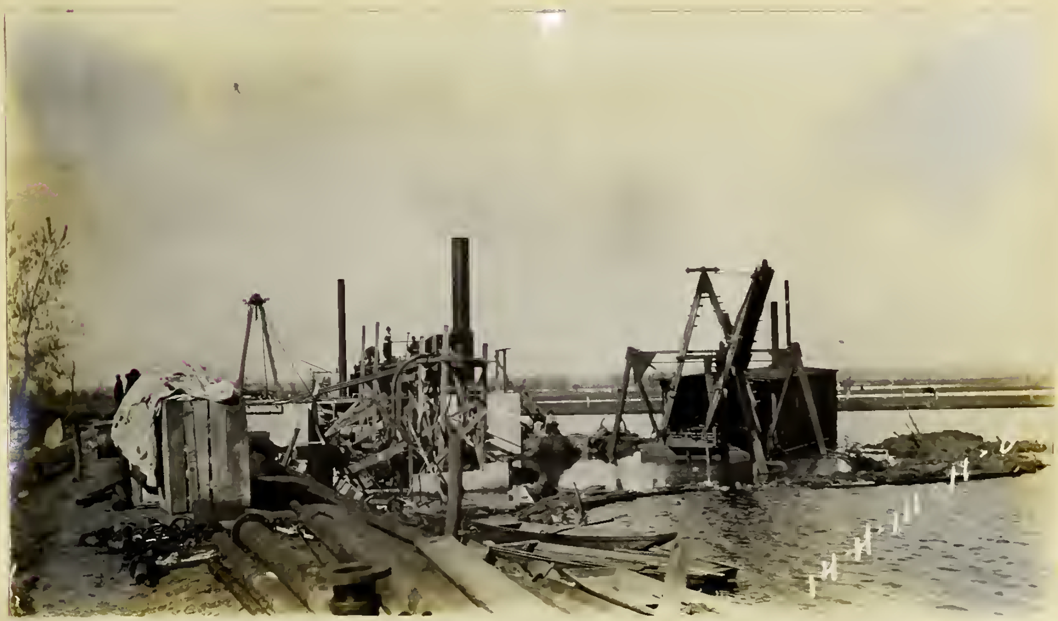

DIGGING SUCTION BAY.

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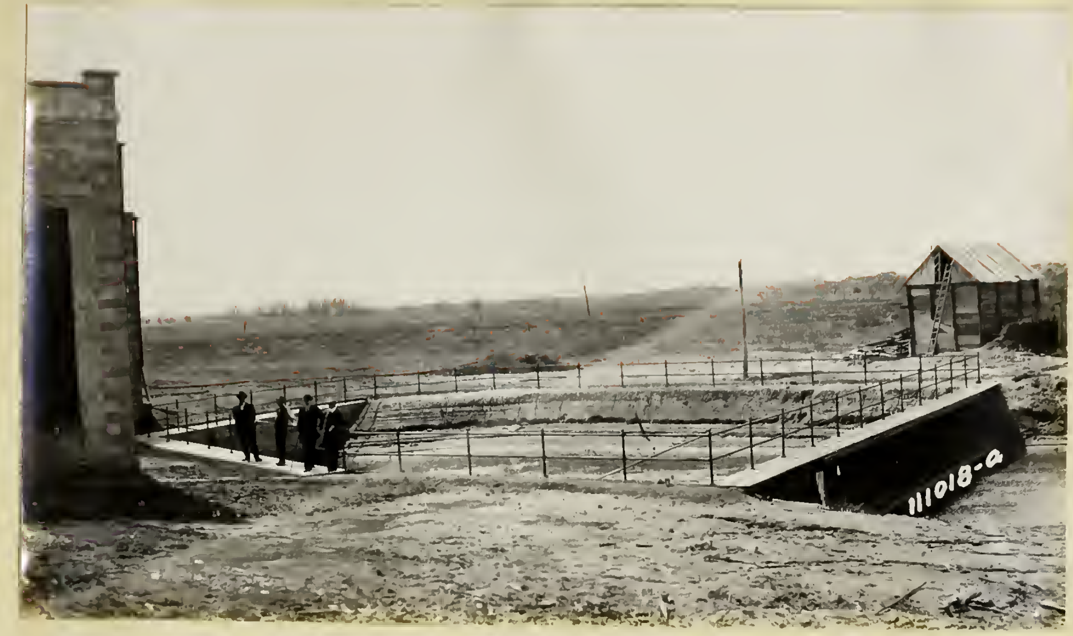
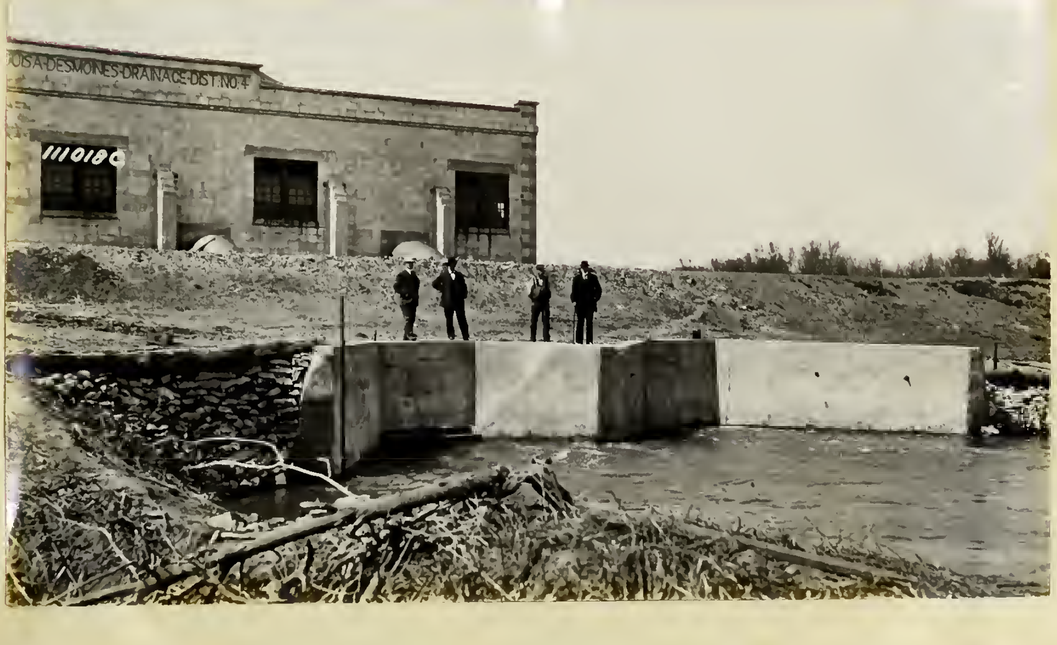


SUCTION BAY.



DISCHARGE BAY.

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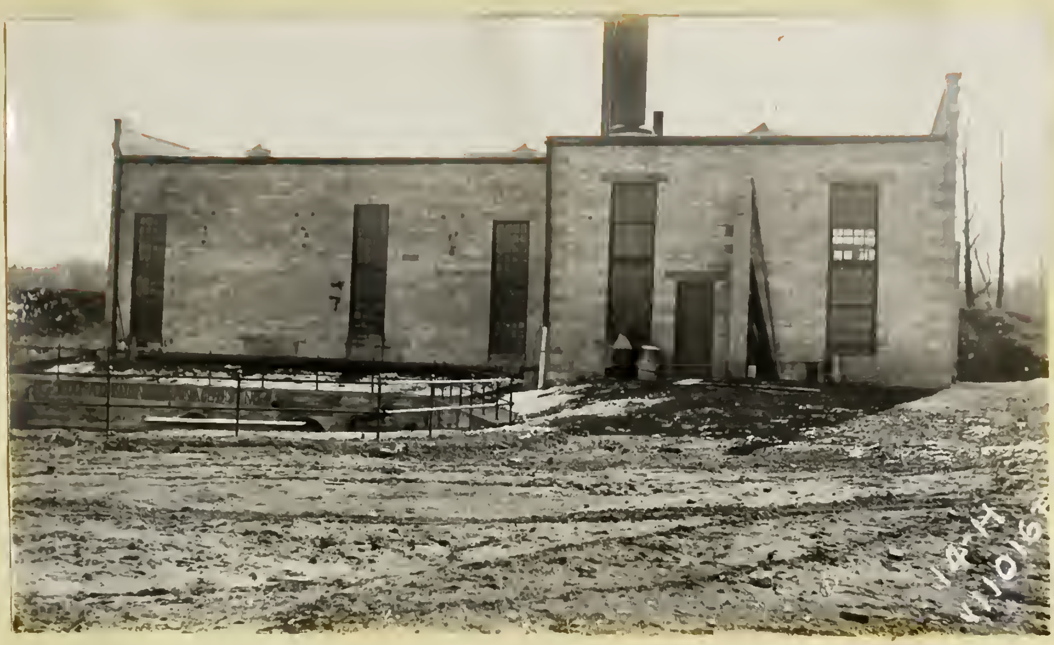
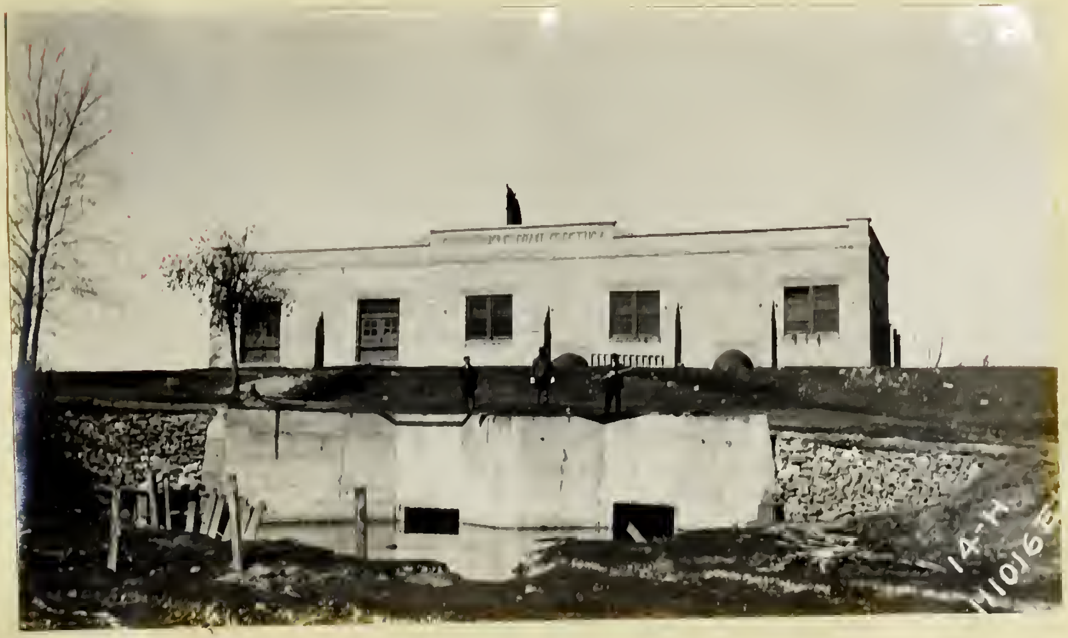


PUMP PLANT



PUMP PLANT.

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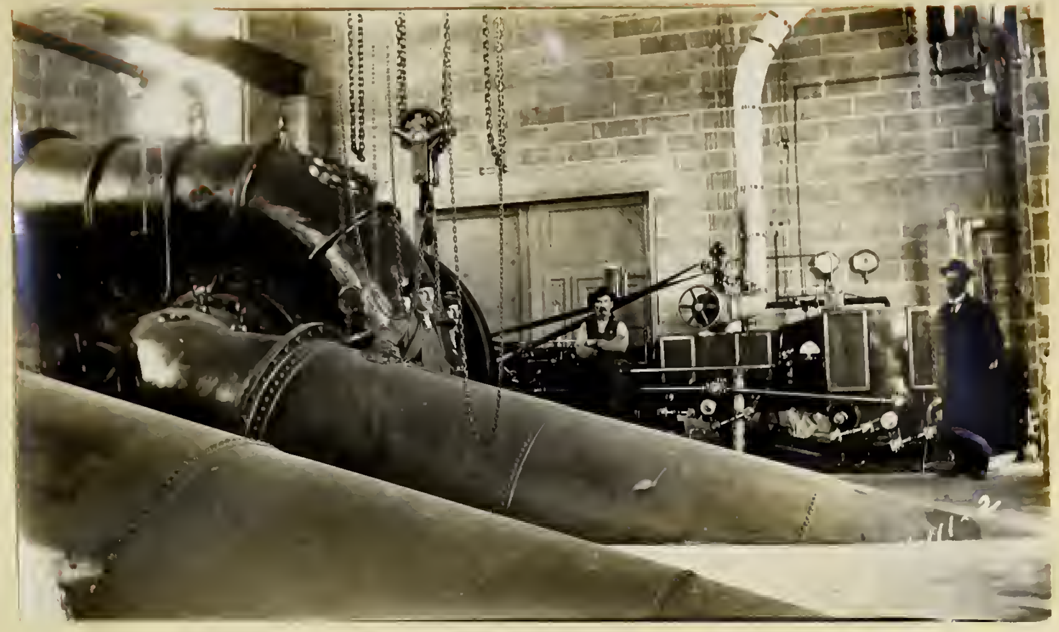
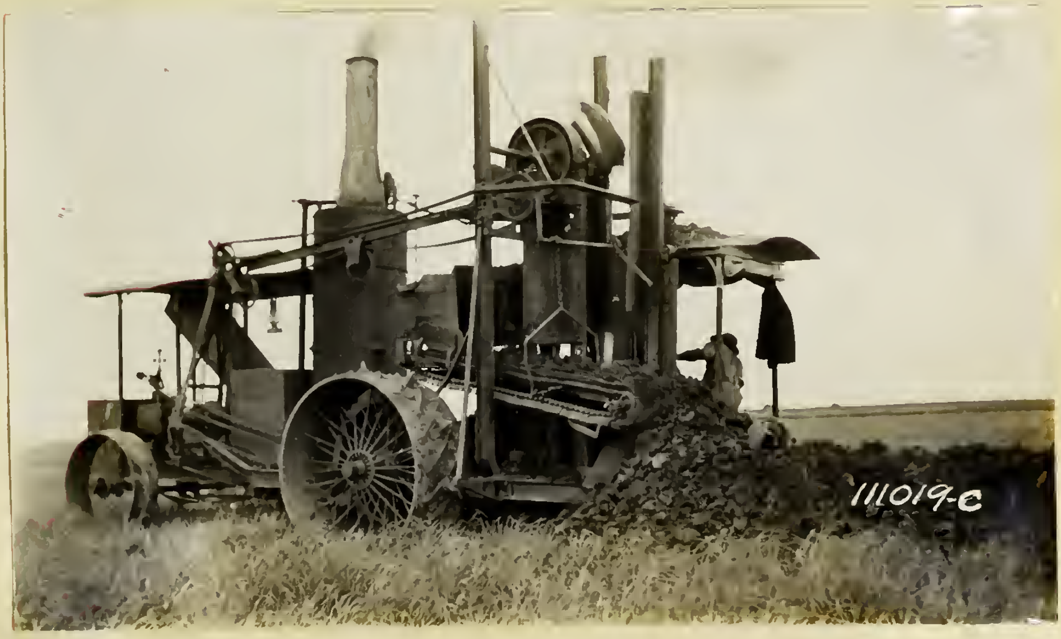
OF THE
UNIVERSITY OF ILLINOIS



INTERIOR OF PUMP PLANT



DITCHING MACHINE.

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